OCTOBER, 1948
Vol. 4 - - - - No. 5

Lubrication ENGINEERING

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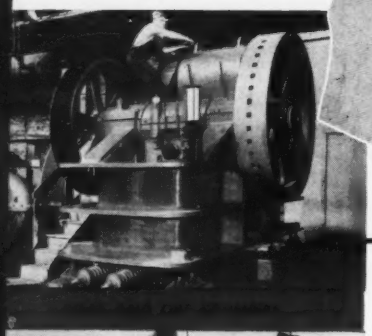
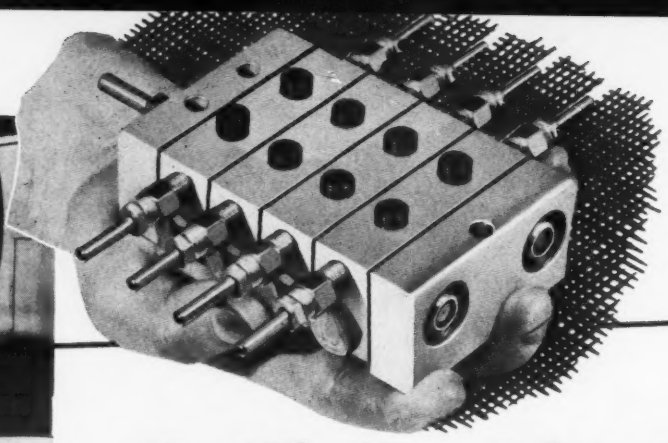
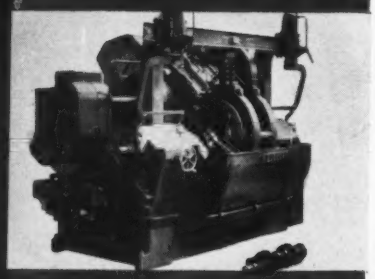
JOURNAL OF THE AMERICAN SOCIETY OF LUBRICATION ENGINEERS

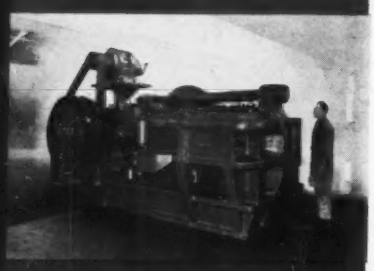


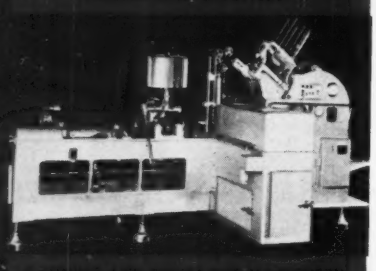


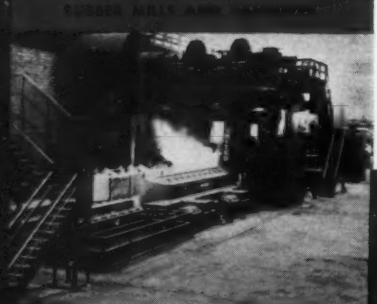


Men Who Know Lubricating Systems *Specify Trabon*

Check these Operating Features and you'll realize why plant engineers and master mechanics prefer Trabon







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- **All-Hydraulic Operation**—Feeder measuring pistons are positively actuated by hydraulic flow of lubricant—no springs.
- **Progressive Operation**—Feeder sections operate progressively, one after the other. Each piston discharges its full measured amount of lubricant before the main hydraulic flow from the pump can reach and operate the next piston. *This makes it impossible to skip or under-lubricate a bearing.*
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- **Rugged, Steel, Sealed Feeders**—Vibration-proof, heavy steel feeders are completely sealed and have no exposed moving parts. The sealed Trabon System can be buried underneath dirt, grime, coal dust or even concealed inside the machinery. For the single indicator at the pump tells the story!
- **Wide Range of Discharges**—Trabon Feeders can provide extreme variations in lubricant discharges. A complete line of manual and automatic pumps meets the needs of lubricating systems of all sizes and types.

Trabon Centralized Lubricating Systems can save you $5 to $8 per bearing per year in man-hours of lubricating time alone! Upwards of 100 bearings can be lubricated from one pumping point in a few moments time. Consistent lubrication will slash your repair bills and eliminate down-time. Write or phone today for detailed information.

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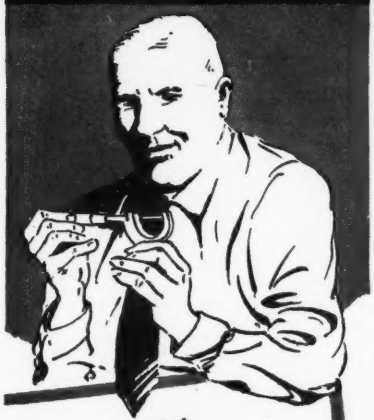
1878 EAST 40TH STREET • CLEVELAND 3, OHIO

TODAY'S METAL CUTTING REQUIRES GOOD CUTTING FLUID



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"CHIP" WRIGHT

Material shortages and other unusual conditions of this post war period emphasize the need for sound cutting fluid practices. Uncontrollable changes in material quality necessitate substitution . . . calling for cutting fluids with wide latitudes and broad tolerances. When you are faced with such machining problems, the smart thing is to use the "know-how" of established cutting oil people. They have the broad, practical experience based on many years of solving difficult machining problems, and the technical knowledge and facilities to apply it to your job.

—Chip

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SUPERKOOL
Base Cutting Oil

SuperKool Base Cutting Oil is available already correctly mixed for your convenience. Eliminating on-the-job mixing makes possible worthwhile economies in time, labor and money. For recommendations of SuperKool mixes, consult a Stuart service engineer.

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Lubrication ENGINEERING

VOL. 4 OCTOBER, 1948 NO. 5

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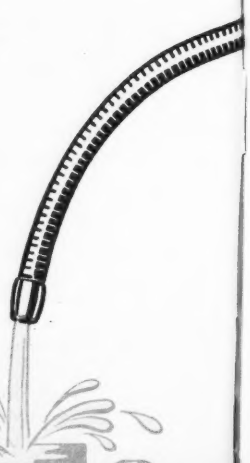

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OF ALL METAL CUTTING JOBS

Silicone News

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In a competitive market your strongest selling point is a superior product. Constant vigilance is required, however, to maintain that superiority. That's why top management men as well as design and production engineers are taking such keen interest in our silicone products.

With this family of new engineering materials, designers are able to do all sorts of previously impossible things. Skillfully used, Silicones can give you a sound, competitive advantage. Take silicone electrical insulation for example.

PHOTO COURTESY AUTOMATIC TRANSPORTATION COMPANY

Skylift Electric Truck motors are wound with DC Silicone Insulation which has 10 times the life and 10 times the wet insulation resistance of Class "B" insulation. DC 44 Silicone Grease in the bearings has about 8 times the life of petroleum grease.

Here's an example of the way Automatic Transportation Company of Chicago capitalizes on the competitive advantage our silicone materials give them. Recent ad copy carries this headline in bold-face type.

Only Automatic Skylift Trucks Give You "BURN-OUT PROOF" Silicone Insulated Motors

Skylift Means Uninterrupted Material Handling

That's good selling copy and it's backed up by the amazing stability of our silicone products in all of their various forms. You may be able to improve or protect your competitive position by keeping in touch with Silicone developments through the branch office nearest to you.

Data on all of our DC Silicone Products is given in Catalog No. P-1-15.

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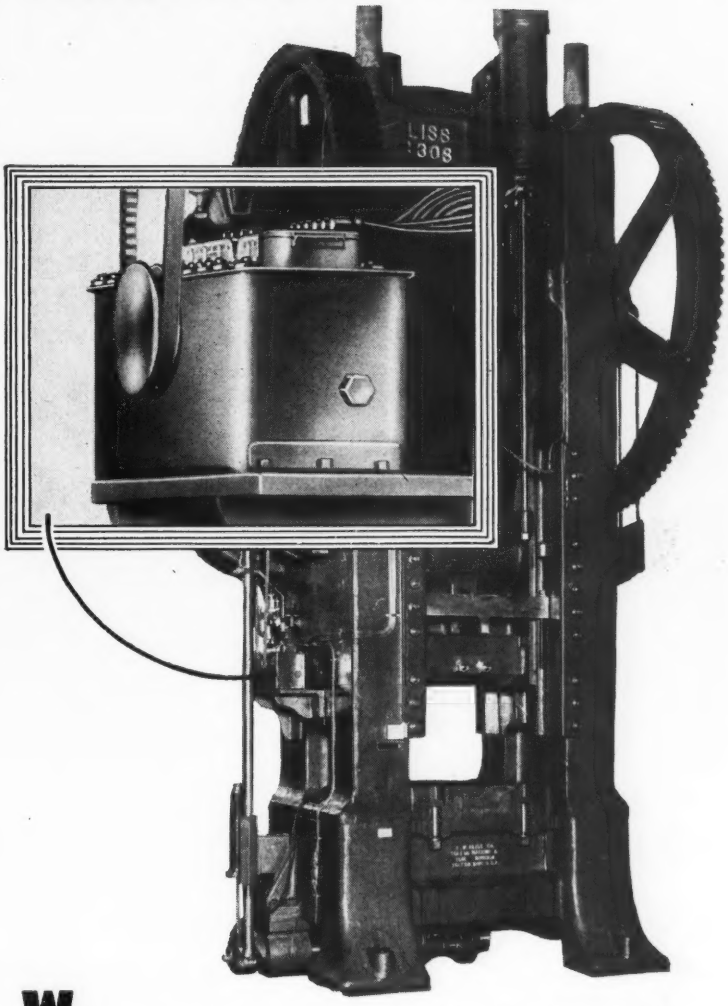

When the 20 hard-to-get-at bearings on this Bliss Crank Press were serviced by an oil can, it took 90 minutes a day at a labor cost of $2.10. In 10 years, with its modest initial cost taken out, this Manzel Model 25 Lubricator saves $5074.40 in labor alone. The oil saved by this non-wasting, never-forgetting guardian runs up to 60%...another *must* for Manzel Force-Feed Lubricators.

Manufacturers and users of pumps, engines and numerous types of heavy machinery have found Manzel Force-Feed Lubricators pay for themselves many times over. You probably have a lubrication job that can be handled much better and far more economically by Manzel equipment. Write us today for helpful information.

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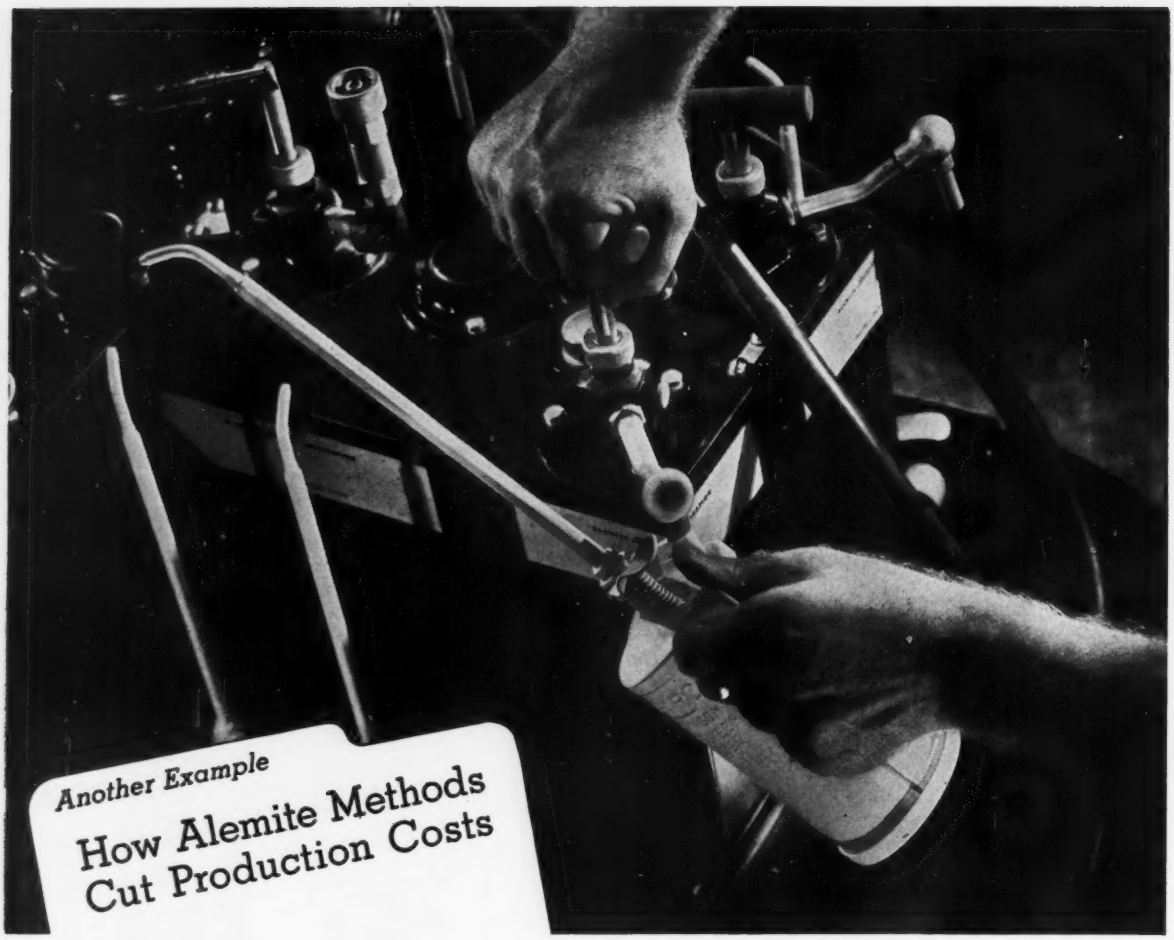
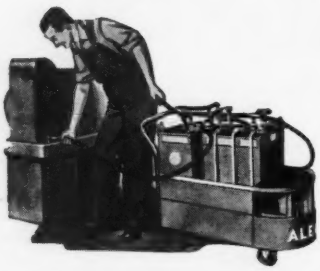


Another Example

How Alemite Methods Cut Production Costs

Slashes Downtime for Lubrication Up to 35.3%



Your Lubrication Methods May Be More Antiquated Than You Suspect

Shown above is an Alemite LubriKart being used to fill a gear case. Compare this modern, compact, efficient unit with your own lubrication methods. If yours fall short—remember that the Alemite Representative is a specialist in modern methods of handling and applying lubricants. A five minute conference with him may open your eyes to new cost-cutting ideas. Call your Alemite jobber or write to Alemite, 1847 Diversey Parkway, Chicago 14, Illinois.

Adds More Productive Time to Machines by Mechanizing the Handling and Application of Lubricants

Your machines demand many different types and grades of oils and greases. That's why you need an Alemite LubriKart—a complete, portable lubrication department on wheels. Everything an oiler needs is within arm's reach. Result—he can service any machine in as much as 35.3% less time—adding more productive time to each machine.

This is just one of many Alemite Methods that help to cut production costs. And the Alemite Representative can quickly prove that his simplification of lubrication procedures definitely reduces maintenance costs in any plant, large or small.

He can show you case after case where a time study analysis proves that Alemite Methods eliminate costly, time-consuming handling of greases and oils. His methods completely mechanize lubrication from-barrel-to-bearing...keep dirt out of grease . . . reduce bearing failures. He can show you how to lubricate as many as 300 bearings from *one* safe central point while the machines keep on producing! Get the complete facts today!

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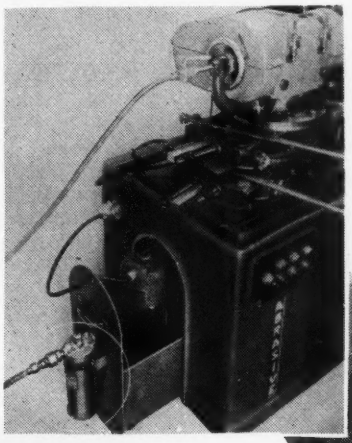
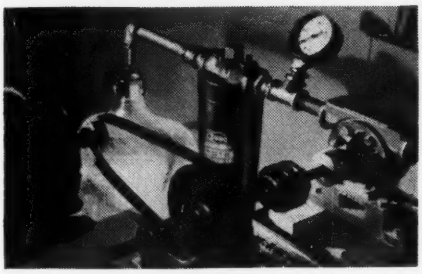
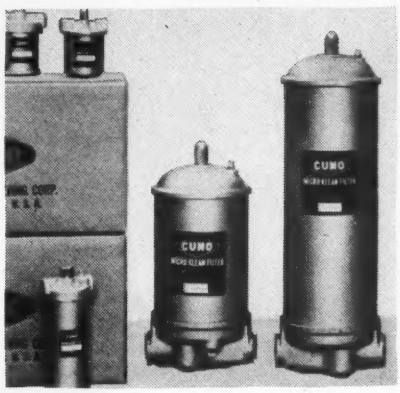
Abrasive Carbide Finisher grinds tungsten carbide to less than 2 millionths of an inch root-mean-square roughness. Metal and abrasive particles which would damage work surface are removed from recirculating coolant by Cuno MICRO-KLEAN Filter.





Handles wide range of fluids

In another application at Teaneck Chemical Co., Cuno MICRO-KLEAN with 25-micron cartridge handles 1-2 gpm of very viscous photographic chemical solution at 65 psi.



Cartridges...Filters...for all jobs

Cuno MICRO-KLEAN filters come in densities of 25 and 10 microns . . . capacities from a few to 850 gpm . . . connections from $\frac{3}{8}$ in. IPS to 6 in. flanged . . . single or multiple cartridges to handle full flow. MICRO-KLEAN cartridges fit other makes; special lengths available for built-in installations.

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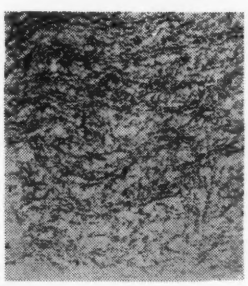
Exclusive fibre construction of Cuno MICRO-KLEAN permits smaller particles to penetrate to varying depths. No surface-loading—graded-density-in-depth increases dirt capacity—doubles cartridge life. Resinous impregnation and polymerization bonds each fibre in position to prevent channeling, rupturing, shrinking and distortion.



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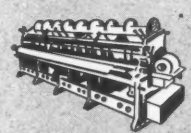

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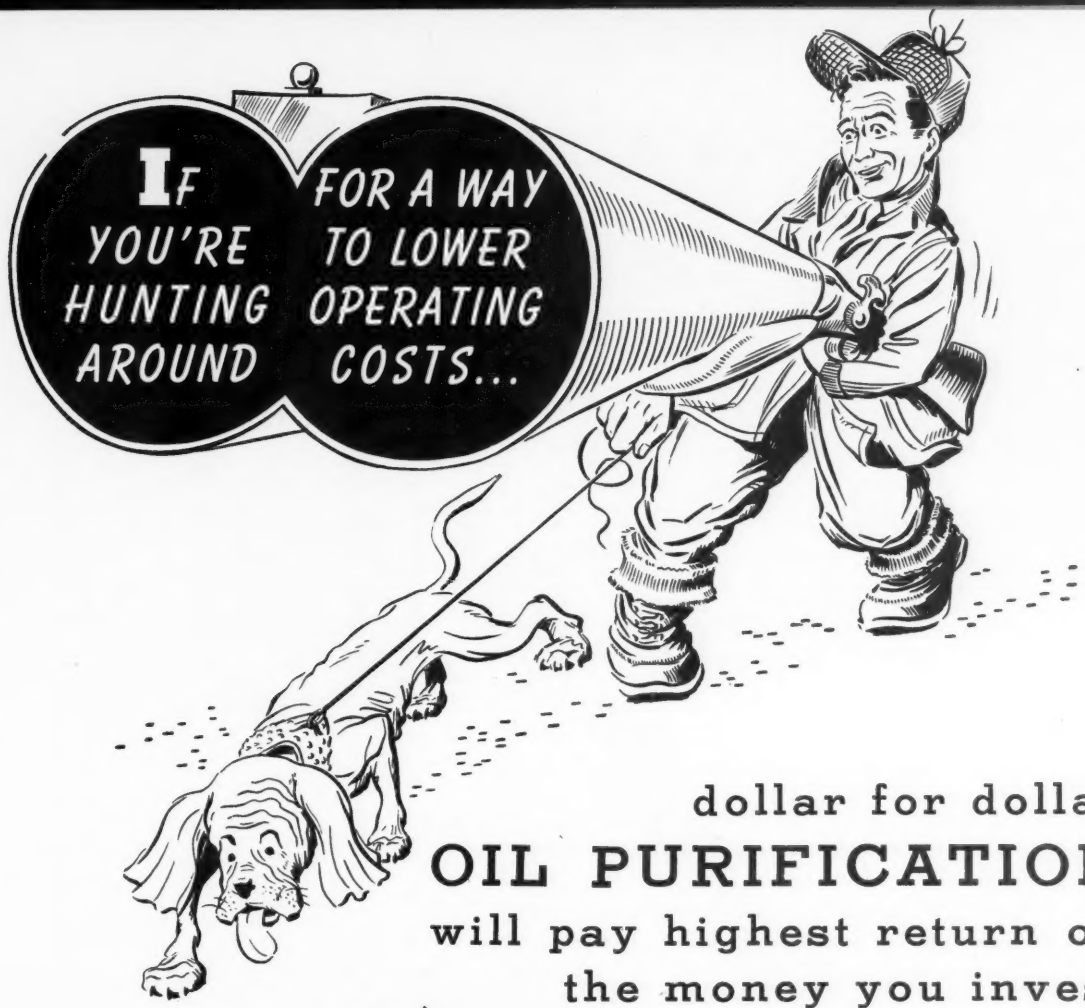

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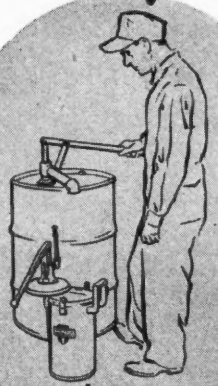
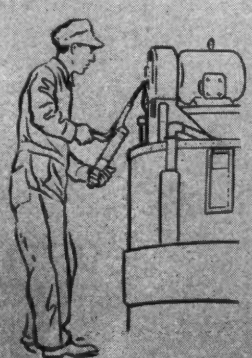


from drum to filler pump 1

from filler pump to grease gun 2



from grease gun to fittings 3

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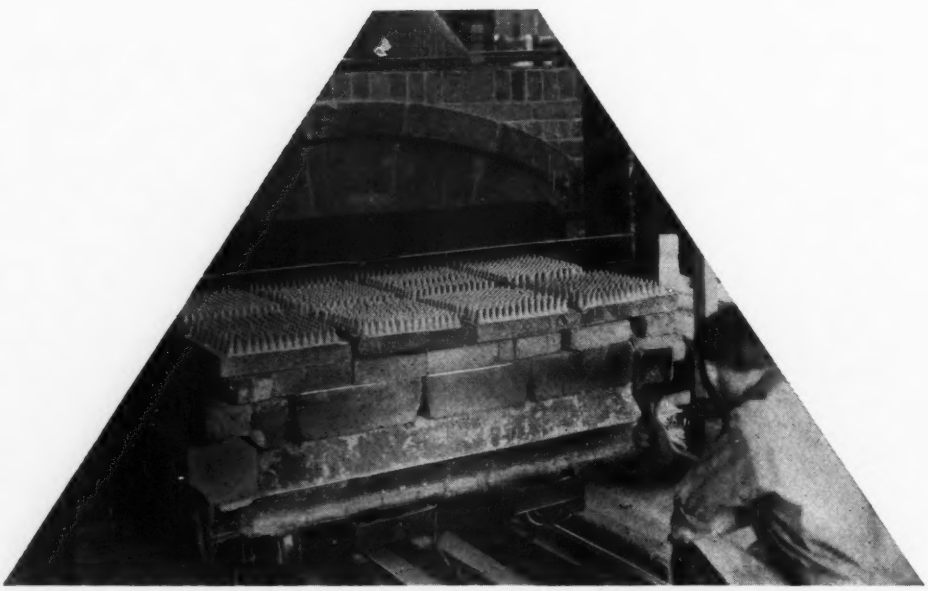

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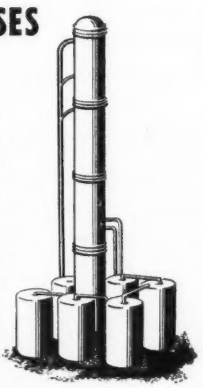

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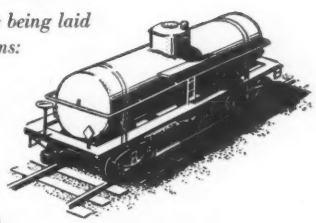

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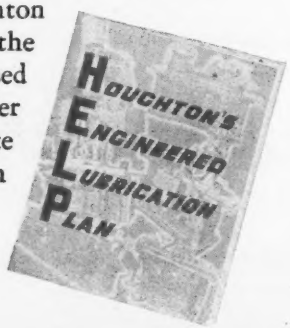


THE EDITOR'S PAGE

(With the press and radio carrying more and more political "hog-wash" as elections approach, a sound break-down of this country's price-wage structure comes as a breath of fresh air. Your editor hopes you will enjoy the following analysis which is an abstract of the fine discussion written by Vice-President Lemuel C. Boulware of the General Electric Co. entitled "Why Are You Paying Higher Prices?")

THERE'S a lot of loose talk about what is causing our present high prices. We don't profess to know all the answers. But here are what we believe to be 10 *definite reasons* for today's high price tags:

1. Government's spending more than it took in.
2. Rationing and price control in war years—without adequate wage control.
3. Necessary shooting away of about half of the country's production in the war years, but failure to tax back from consumers—to take out of existence—the extra bonds and money printed during the war to pay for that war production.
4. High cost of government in peacetime—taking almost 20% of the country's production and income.
5. Paying subsidies to put and keep prices up—even in a seller's market.
6. Round after round of post-war general wage increases to most everybody—thus diluting further the value of money because there was no corresponding individual contribution to increased production.
7. Too-anxious consumer demand for available production.
8. Spending of savings and too much unnecessary buying on credit.
9. Needed aid to Europe, and re-armament.
10. Lowered taxes on individuals—which freed extra money for further upward pressure on prices.

For 16 out of the last eighteen years we Americans have had our government follow a policy of spending more than it took in. This spend-thrift policy has left us with a new debt of over $250 billion in bonds and extra "printed" money for which there are no goods. That's more than the whole output of everybody in the United States for a whole year. We are also having our government take about $40 billion from us each year—about $10 worth of goods and services out of each $50 worth produced; about $10 directly or indirectly out of each $50 pay check. For a while everybody was fooled. We enjoyed it until we suddenly realized that all too often our new $2.00 was buying even *less* than our old $1.00 did before the value of our money was diluted.

During the war years, we *gave* away or *shot* away about half the output of the country. The government paid for this half with extra money and bonds printed to cover the difference between what the government was spending and what the government took back in taxes. Thus the actual goods disappeared while the money paid for them remained hanging over the market. The money left from this high war and post-war income, and the lack of a corresponding supply of consumer goods resulted in an enormous demand for what products there were.

One way we, through our goverment,, have kept food prices rising is in the use of the public's money to subsidize agricultural products. For example, we now see potatoes being bought with our money by the government to keep the price up—these potatoes to be resold by the government at 20c *a ton for hog* food while we pay 10c a pound, or $200 a ton, for those we eat as human food. Likewise, we saw the recent heavy buying of eggs by the government to support egg prices—already 75c to 85c a dozen at the grocery—when there are millions and millions of eggs in dried storage previously bought by the government to keep egg prices up.

Subsidies to farmers were the desire of the majority of the people some time back—and may still be. But we are certain the farmers themselves are not for any unwise abuse of the subsidy idea at a time when the country faces *high* prices— and not *low* prices which the subsidies were originally intended to remedy.

It was only natural that the first reaction of most of us was that we wanted more income to meet these rising prices *we* had created through *our own* unwise actions individually and through our government.

But our problem is not one of income. Our trouble is that too many of us are taking some of this extra money from our savings and adding it to our incomes to buy our present output. Also, too many—where it isn't really necessary—are going into debt.

Not only is the dilution in the value of money from the new third round of general wage increases already being felt, but there is an extra $5 billion in personal tax reductions coming into the market to compete further for what goods there are. But there are now *less* goods available to consumers in proportion to total production—because of the new aid to Europe and the new military preparation program.

Prices will not come down—or even level off—except as we get *both* more and more production *and* less and less frantic, heedless, expensive *bidding up* of what production is gotten out.

We have got to make up our minds to do both these things *voluntarily* if we want them done. We Americans are not easily *forced* by government to do anything a majority of us have decided we don't want to do.

Here's what we have each got to do—we believe—if we are to solve this critical problem intelligently, honestly, patriotically—and with just pure individual selfish good sense:

1. Each of us has got to restrain himself sensibly in his own and his country's interest. We can't make a good deal when we are mad or in a hurry or too obviously willing to pay *any* price. We have got to stop wasting our present savings and make new savings.
2. Each of us has got to tell his representatives in government that we want to pay as we go—have no more overdrafts or "deficit financing" even for short periods; that we want real waste elimination and economy in government; that we want our huge debt managed wisely and reduced gradually; that we want government purchases made prudently without favor.
3. Each of us as an individual worker or manager must produce more—exercise ingenuity and effort to give a bigger and better value—in full realization of how that is for the good of *each* and *all*.
4. Each business man must "save" or hold back a substantial portion of earnings and plow them into expanded and improved equipment and methods to increase output per worker—as well as total production.

We believe that's the only way . . . the voluntary and intelligent way . . . the American way . . . with work, thrift, self-control . . . by which each and all of us together can cure high prices and go on to the higher standard of living we are so capable of achieving.

The Mechanism of Friction and Lubrication*

By J. J. BIKERMAN

MERCK & CO., Inc.

Mr. Bikerman is a physical chemist whose work deals mainly with surface phenomena. The title of his recent book, "Surface Chemistry for Industrial Research", published in December 1947, gives an idea of his interests.

He was born in Russia, graduated at the University of (then) St. Petersburgh, and lived in Germany and Great Britain before coming to U. S. A. in March 1945. Now he is employed in the Research and Development Division of Merck & Co., Inc.

His first contact with friction was in 1938 in Cambridge, England, when he became familiar with the work of W. B. Hardy and his school. Hardy's conception immediately struck him as improbable and for 10 years now he has tried, as far as his professional occupations permitted, to prove that friction and lubrication are chiefly mechanical, not chemical, effects.

I. Introduction

THE mechanism of friction and lubrication is of little concern to a lubricating engineer absorbed in his daily tasks, but its knowledge would be highly useful in any research on lubrication. Unfortunately, this knowledge is far from being satisfactory. Not only are different interpretations advanced by different scientists for observations which by common consent do belong to the field of friction and lubrication, but the boundaries of this field are not delineated, and many experiments performed by one school to test a theory of friction do not, according to the opposite school, involve friction at all.

The two main schools of thought emphasize, one, the molecular, and the other, the mechanical aspects of friction and lubrication. The following review is arranged in accord with the "mechanical" theory but the "molecular" explanations are given as well to protect the reader from the pronounced bias of the author.

Consider two solids whose flat surfaces are in contact, see Fig. 1. When one of these solids is shifted tangentially (arrow in Fig. 1), the resistance encountered is often termed friction. If a substance deposited between the solids lowers this resistance, it is generally termed a lubricant. A good part of the disagreement between investigators is due to the fact that the "key" words *contact* and *friction* have different meanings for different persons.

However, there exists a region of general concord. When the two solids are separated from each other by a liquid film so thick that the properties of the bulk of the liquid are not affected by the solids, then only the liquid is involved when tangential shift takes place and the resistance to sliding is determined only by the viscosity of the liquid. This is the region of hydrodynamic lubrication explored by Petroff and Osborne Reynolds. Its rules are not contested, can be found in text-books and will not be discussed in the present report.

*Paper presented at 3rd Annual A.S.L.E. Convention, Buffalo, N. Y., April 21, 1948.

II. Thin Film Lubrication

When the liquid layer between the two solids of Fig. 1 is thin, the hydrodynamic theory ceases to be valid. The transition between the thick and thin film lubrication and the main feature of the latter can be illustrated best by two kinds of experiment. In one of these the solids form a journal bearing the clearance of which is filled with lubricant; and in the other the solids are flat.

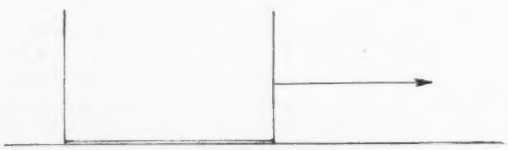


Fig. 1 Simplest Friction System

Fig. 2 taken from A. Sommerfeld[1] shows the dependence of the friction in a journal bearing on the film thickness. The abscissa of the figure represents $\left(\frac{r}{d}\right)^2 \frac{\eta U}{P}$, r being the radius of the journal, d the average clearance between brass and shaft, η the viscosity of the lubricant, U the peripheral speed of the shaft, and P the load carried by unit length of the journal. The ordinate is rf/d, f being the coefficient of friction. The broken straight lines marked Coulomb and Petroff indicate the predictions of Coulomb's and Petroff's laws, and the continuous curve corresponds to Sommerfeld's theory. It is seen that the experimental value of rf/d is much greater than the theoretical at values of $\left(\frac{r}{d}\right)^2 \frac{\eta U}{P}$ below about 0.07. When the

[1] A. Sommerfeld, *General Discussion on Lubrication and Lubricants. Institution of Mechanical Engineers*, London, 1937, I, 299.

[2] O. Wittrock, *Oel und Kohle, 13*, 979 (1937).

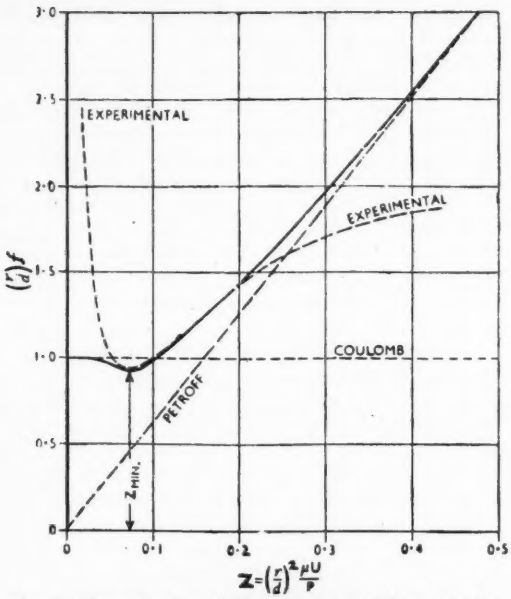


Fig. 2 Theoretical and Experimental Values of Friction in Journal Bearings (From A. Sommerfeld, "Lubrication and Lubricants", Vol. I, London, 1937)

pressure P is great, that is when the minimum film thickness within the bearing is small, the coefficient of friction f increases instead of remaining constant as required by the theory. However, the theory can yet be valid also at small clearances if the assumption of a constant viscosity is dropped. Let us suppose, for instance, that the actual viscosity of the film at $rf/d=2.0$ is 15 times the viscosity of the lubricant in bulk. This would increase $\left(\frac{r}{d}\right)^2 \frac{\eta U}{P}$ from about 0.02 to about 0.3, and the experimental curve would fall on the theoretical curve.

Observations agreeing with the curve marked "experimental" in Fig. 2 are numerous. We may state then that thin liquid films under certain conditions behave as if they had an abnormally high viscosity.

O. Wittrock[2] and S. J. Needs[3] measured the rate of approach (along the cylinder axis) of two plane, circular, parallel plates under the action of an external force, when the s'it between the plates was filled with a lubricant. The theory of this rate was developed by J. Stefan[4]. If h_1 is the original distance between the plates, then this distance is reduced to h_2 within the time t given by $t = \frac{3}{4}\frac{\pi\eta a^4}{W}\left(\frac{1}{h_2^2}-\frac{1}{h_1^2}\right)$, a being the radius of the plates and W the total force causing the approach.

Fig. 3 illustrates the results obtained by Needs with steel discs in olive oil. The abscissa shows time in hours, and the film thickness h^2 is plotted along the ordinate. It is seen that in 3 tests out of 4 the experimental rate of approach lags behind the theoretical as soon as h^2 becomes less than about 8×10^{-5} inch (2×10^{-4} cm.) In Wittrock's work the rate of approach started to deviate from theory at distances of about 5×10^{-4} cm.

Here again the agreement with the theory can be restored if one assumes that the viscosity of thin films is greater than that of the liquid in bulk. Many other effects, not directly connected with lubrication, point

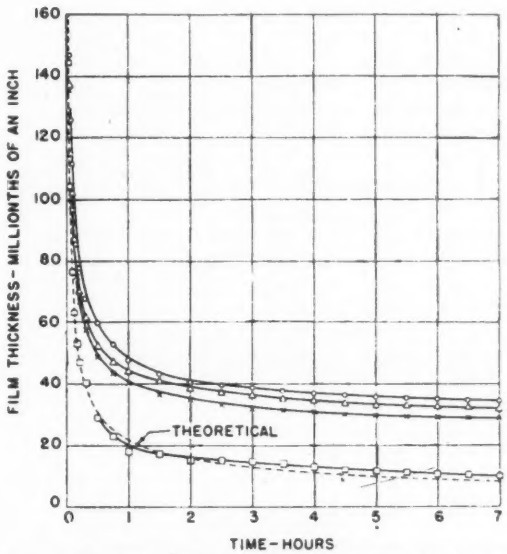


Fig. 3 Descent of Heavy Plate in Viscous Oil (From S. J. Needs, Trans. ASME, Vol. 62, 1940)

in the same direction—thin liquid films between two solids (or also at solid-liquid and solid-gas interfaces) are less mobile or more "rigid" than thick films of an identical liquid. A review of these phenomena can be found in my recent book "Surface Chemistry for Industrial Research" and cannot be repeated here. Only the two rival explanations of these "immobile" or "rigid" layers are compared here.

The "molecular" point of view first taken by W. Hardy can be expressed in the words used by Needs: "The nature of this separating film is not known but experimental evidence indicates that the proximity of the metal surfaces has a profound influence upon the forces normally acting between the molecules of the liquid. . . At the present time there is no direct experimental evidence that rigidity is due to oriented molecules. But the rate at which rigidity builds up and the rate at which it is removed by shear points to the possibility of molecular rearrangement. . ."

The "mechanical" theory[5] attributes the existence of "immobile" layers to surface roughness which can be intensified by dust so often present on solids. As solid surfaces are rough, the liquid next to a solid surface cannot move in a truly laminar manner; it meanders between elevations, forms eddies and vortices, etc. Its speed, therefore, is less than it would have been in a liquid adjacent to a perfectly smooth surface postulated in the theory of laminar flow. The irregular movement of liquid between the hills and through the valleys on solid surfaces causes also the effect of surface roughness on turbulance. The rougher the surface, the smaller

[3] S. J. Needs, *Trans. Am. Soc. Mech. Engrs., 62,* 331 (1940).
[4] J. Stefan, *Sitzber., Akad. Wiss. Wien,* math.-naturwiss. Klasse, Abt. II. *69,* 713 (1874); see also J. J. Bikerman, J. Colloid Sci., *2,* 163 (1947).

[5] See the review by J. J. Bikerman, *Rev. Modern Phys., 16,* 53 (1944).

the speed of flow at which turbulent motion supplants laminar motion.

If the enhanced viscosity revealed by deviations from Sommerfeld's curve, Fig. 2, is a consequence of roughness, it may be expected to appear at greater film thicknesses the rougher the surface. This deduction was confirmed in the experiments by J. T. Burwell, J. Kaye, D. W. van Nymegen and D. A. Morgan[6]. They studied steel journals running in babbitt metal bearings. The journals were either turned, or ground, or "superfinished." Their degree of roughness was measured with a tracer instrument and expressed as the root-mean-square height h_{rms} of the asperities. In Table I two values of h_{rms} are given. The first is valid for the direction normal, and second to that parallel to the direction of motion. The last column shows the values of $\left(\frac{r}{d}\right)^2 \frac{\eta U}{P}$ at which the coefficient of friction f had a minimum value. When the value of $\left(\frac{r}{d}\right)^2 \frac{\eta U}{P}$ was smaller than that shown in the table, i. e the pressure was great and the minimum film thickness small, then f was greater than calculated by Sommerfeld. It is seen that the deviation from theory starts at lower pressures the greater the value of h_{rms}.

TABLE I.

Position of the minimum of friction for surfaces of different roughness.

Surface	h_{rms} (normal) 10^{-5} cm.	h_{rms} (normal) 10^{-6} inch	h_{rms} (parallel) 10^{-5} cm.	h_{rms} (parallel) 10^{-6} inch	$\left(\frac{r}{d}\right)^2 \frac{\eta U}{P}$ at minimum
Turned	33	130	13	50	0.38
Ground	18	70	18	70	0.25
"	13	50	13	50	0.06
"	4	14	..	..	0 0017
"	3	13	..	..	0.0013
"	2	7	2	8	0 0012
"	1	4	1.5	6	0.0010
"Superfinished"	0.3	1	..	..	0.0008-0.0011

According to the "mechanical" theory the enhanced viscosity of liquid films adjacent to solids is as a rule apparent only. However, many such liquid films undoubtedly possess also a real viscosity of an unexpectedly high magnitude. This effect seems to be due not to any hypothetical orientation of molecules but to ordinary chemical reactions. When, e.g., a mineral oil containing fatty acids is spread over a copper or iron surface, the metal-oil boundary gradually becomes coated with a film of copper or iron soap which has a much higher viscosity than the bulk of the oil.

A neat indication of the existence of such soap films was found by A. Boutaric and R. Amiot[7]. They covered flat triangular pieces of metal with an oil film, centrifuged the plates, and determined the amount of oil remaining on the metal after a definite time. This amount agreed with the calculation assuming the oil to have its normal viscosity, as long as the residual film was moderately thick. When the film was very thin, the oil ceased to be thrown off the plate thus simulating an abnormally high viscosity. The film thickness below which the viscosity was too great, was greater for acid than for neutral oils and greater for iron and copper than for aluminum and stainless steel. Films of, e.g., acid oil on copper were abnormally viscous at greater thicknesses than films of neutral oil on stainless steel.

The thin film lubrication as discussed above may be said still to belong to hydrodynamic lubrication. In both regions—of thick and of thin films—the friction is determined by the mobility of the liquid making up the film. When the film thickness is great, this mobility is a definite function of the bulk viscosity of the liquid. When the film thickness is small, the mobility depends also on the roughness of the solid surfaces bounding the film; if the solids chemically modify the liquid, the mobility within the film is affected also by its altered chemical composition.

III. Transition to Dry Friction

The generalized hydrodynamic explanation of the thin film lubrication cannot be valid when the distance between the two solids is so small that hills on one of the solids cannot clear those of the other solid. In this region the terms *film thickness* and *distance* must be used with great caution. In Fig. 4 a schematic profile is drawn of two solids (shaded) between which a very small amount of lubricant is confined. The lubricant layer at the left end of the drawing has the average thickness; in the adjacent portion to the right there is an air bubble above the liquid; and further right the solids are in so-called contact, see Section 4, and the film thickness is only a small fraction of the mean thickness. The distance between the solids has the average value at the extreme left, a much greater value across the air bubble, and is almost zero at the point of "contact."

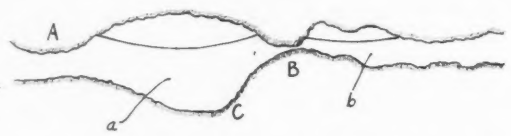


Fig. 4 A Typical Profile of Two Lubricated Surfaces in Contact

Suppose the lower solid (support) of Fig. 4 to be stationary and the upper solid (slider) to move to the right. The hill A probably will fall into the lubricant pool *a* and will have to climb over the hill B before reaching the lubricant *b*. The force required to pull the slider parallel to the main surface of the support is expended mainly on lifting the slider over the numerous hills of the latter. At least such is the belief of the adherents of the "mechanical" theory.

When a heavy body is pulled up along an inclined plane, the force pressing the body against the plane (i.e., the normal load N) is $W\cos\alpha$, if W is the weight of the body and α the angle of slope of the plane. The force F required for pulling up is $W\sin\alpha$ or $N\tan\alpha$. The coefficient of friction F/N is equal to $\tan\alpha$. The normal load N cannot be altered by lubrication, but the angle α can.

Consider again Fig. 4. If the space between slider and support is filled with air, and the slider is pulled to the right, the hill A will descend as deeply as the contacts between other hills would allow. It may descend to the bottom of the valley between A and B: then it will have to ascend the hill B starting with the steep slope at C. When there is a lubricant on the surface of the support, the hills on the slider surface descend more slowly because the viscosity of the lubricant is greater than that of air. The geometry of the

[6] J. T. Burwell, J. Kaye, D. W. van Nymegen and D. A. Morgan, *J. Applied Mechan., 8,* 49 (1941).

[7] A. Boutaric and R. Amiot, *Compt. rend., 193,* 593 (1931).

system is so complicated that no calculation of the rate of descent is possible, but some information can be gained from Stefan's equation (see p. 209). This equation shows that the time required to reduce the distance between two solids to a small value h_2 is inversely proportional to h_2^2 (we neglect the term $1/h_1^2$). When h_2 is small, e.g. 10^{-6} cm., t is relatively great even when the viscosity η has a moderate value. If the time required for the hill A to reach the bottom of the pool a is large compared with the time of its tangential translation to a "contact" with hill B, then the lowest part of A will be only slightly lower than the summit of B and only a small amount of climbing will be necessary[8].

If this interpretation is essentially correct, two results among others may be expected. If the viscosity of the lubricant is not too high and the slider is left undisturbed on the support for a sufficient time, the slider's hills will sink into the valleys of the support as far as the geometry of the surfaces allows, independently of the exact magnitude of the viscosity. It follows then that static friction between two lubricated metals may, when the above conditions are fulfilled, be independent of the viscosity of the lubricant. On the contrary, the kinetic friction should be smaller the greater the viscosity because the time t of descent increases with viscosity. Both these expectations seem to be confirmed by W. E. Campbell's experiments[9]. Campbell compared two mineral oils the viscosities of which were in the ratio 1:27. The static friction between steel balls and four different bearing metals was almost independent of the oil, but the coefficient of kinetic friction was 0.10, 0.09, 0.085 and 0.095 for the more viscous and 0.16, 0.14, 0.13 and 0.12 for the less viscous oil. Fatty oils behaved differently but they probably formed soap films on the metal surfaces and the viscosity of the lubricant next to metal was much higher than the bulk viscosity.

It would not be correct, however, to conclude that in this region of lubrication the friction must be smaller the greater the viscosity. When the slider separated from the support by a film or by patches of lubricant moves relatively to the support, the lubricant is sheared and the force expended on this shearing increases with the viscosity of the lubricant. When the viscosity is great, the frictional force due to resistance of the liquid may become greater than that used to lift the slider over the hills of the support. Probably, clear instances of this kind are described in the literature, but none could be found by the present author.

From the point of view of the mechanical theory the ideal lubricant should simultaneously offer (a) a strong resistance to the immersion of the hills of the slider into the valleys of the support and (b) a negligible resistance to the movement of these hills parallel to the main surface of the support[5,8]. In other words, the lubricant should have a high viscosity normal to the surface and a low viscosity parallel to it. This striking combination of properties was described in the literature, see, e.g., G. Friedel[10]. Smectic phases, the molecules of which have the tendency of a spontaneous parallel orientation, are more viscous along the direction of orientation than across this direction. Many soaps were shown to form smectic phases, and soaps belong to classical lubricating agents in the transition range discussed here. Electron diffraction studies[11,12] made probable a correlation between the performance of a "boundary lubricant" and its degree of orientation at solid surfaces.

The importance of molecular orientation should not be exaggerated, however. Water never appears as a smectic phase but is an efficient lubricant for the pairs rubber-rubber, rubber-glass, mica-mica and others.

According to the "molecular" theory friction between unlubricated surfaces is due to attraction between the surface atoms of the two bodies in contact. On this view, the function of the lubricant is to intercept these attractive forces.

Two effects were described in the literature as proving the "molecular" nature of lubrication. One is the lubricating effect of unimolecular layers, and the other, the increase of lubricating efficiency with the molecular weight of the lubricant.

A single layer of molecules coating all the hills and valleys of a solid surface cannot markedly alter its profile and, therefore, should not affect its frictional properties if the "mechanical" theory is correct. But it can reduce the intensity of interatomic forces attracting one solid surface to the other and its effect on friction would be in best accord with the "molecular" theory. To understand properly the meaning of the experiments involving "unimolecular" layers we must know how they are prepared.

Two methods of preparation were used in friction measurements. (1) A droplet or speck of lubricant is smeared over the solid surface and vigorously rubbed with several changes of cloth or paper. This procedure was used, for instance, by E. N. Dacus, F. F. Coleman and L. C. Roess[13]. These investigators noticed, however, several effects which, in the reviewer's opinion, clearly prove that films produced in this way are in no way unimolecular. In all probability, they contain many more molecules than a true unimolecular layer. Any production of true unimolecular films by rubbing down is extremely improbable in the light of our knowledge of solid surfaces. (2) A slide of metal, glass or another suitable material is immersed in, and immediately withdrawn from, an aqueous solution through a unimolecular soap film on the surface of this solution. By a judicial selection of the conditions or by changing the concentration of the soap film between immersion and withdrawal it is possible to make sure that the slide picks up a unimolecular film on one trip only. This device was used, for instance, by T. P. Hughes and G. Whittingham[14] and by J. N. Gregory and J. A. Spink[15]. However, it was shown earlier[16] that films obtained in this manner are, immediately after application, stretched between the hills on the solid surface and, later, form small crystals or gel particles. At no moment do they form a true unimolecular film covering uniformly the whole of the solid surface. The amount transferred onto the solid is insufficient to cover it completely because the actual surface area of the solid is greater than its geometrical area. Therefore, if interception of molecular forces were the essential mechanism of lubrication, the films produced in this manner should have no lubricating effect.

[8] J. J. Bikerman, *Petroleum* (London), *7*, 150 (1944).

[9] W. E. Campbell, *Trans. Am. Soc. Mech. Engrs., 61*, 633 (1939).

[10] G. Friedel, *Ann. de physique* (9), *18*, 273 (1922).

[11] G. I. Finch and F. D. Zahoorbux, *General Discussion on Lubrication and Lubricants, Institution of Mechanical Engineers*, London, 1937, II, 295.

[12] L. T. Andrew, *Trans. Faraday Soc., 32*, 607 (1936).

[13] E. N. Dacus, F. F. Coleman and L. C. Roess, *J. Applied Phys., 15*, 813 (1944).

[14] T. P. Hughes and G. Whittingham, *Trans. Faraday Soc., 38*, 9 (1942).

[15] J. N. Gregory and J. A. Spink, *Nature, 159*, 403 (1947).

[16] J. J. Bikerman, *Proc. Roy. Soc.*, London, A *170*, 130 (1939).

The increase of the lubricating efficiency with the molecular weight of the lubricant was emphasized by W. Hardy and I. Bircumshaw[17] This observation was considered a proof of the molecular theory of lubrication in the range next to dry friction. It was argued that the longer the molecule separating the two solids, the greater is the distance between them and consequently the smaller their interaction. But the relation between the length of a lubricant molecule and the efficiency of the lubricant is not as general as Hardy believed. J. R. Bristow[18], for example, found ethyl acetate (having a C_2-O-C_2 chain) in certain conditions to be a more efficient lubricant than ethyl propionate (having a C_3-O-C_2 chain). R. Schnurmann and E. Warlow-Davies[19] observed identical values of the coefficient of friction for methyl acetate (C_1-O-C_2 chain) and amyl acetate (C_5-O-C_2 chain). See J. J. Bikerman[5] for additional references. When the efficiency does increase with molecular weight, many other explanations are possible instead of that given by the molecular theory. The molecular weight affects the viscosity, the chemical reactivity and other properties of the substances, not only the length of their molecules.

IV. Dry Friction

In the region of dry friction *the law of friction* is valid. It says that (a) the coefficient of friction is independent of the normal load and (b) the coefficient of friction is independent of the apparent area of contact. The mechanical theory identifies the coefficient of friction with the tangent of the average angle of slope of the surface hills over which the slider must climb. This mechanism immediately accounts for both halves of the law of friction. In addition, it makes clear the cause of 7 other observations[5].

(1) The numerical value of the coefficient of friction usually is between 0.1 and 0.5 corresponding to the angles of slope between 6° and 26°. "Their meaning is that it is very difficult to prepare a surface on which no facet is inclined relatively to the basic plane at less than, say, 6°, and on the other hand, that surfaces showing irregularities steeper than 26° are avoided in frictional experiments." (2) The temperature coefficient of dry friction is very small as long as the temperature remains well below the softening range of the solid[20]. (3) The coefficient of friction is independent of the material of which the solids are made; various metals, various woods and various minerals, all can have the coefficient equal, for instance, to 0.3. (4) The coefficient of friction generally is greater the rougher the surface. (5) The reproducibility of friction measurements is poor because at every subsequent experiment the slider must climb over different hills. (6) The first part of the law of friction is not valid if the load is too small or too great; in the first instance the "slider" (e.g., a dust particle) is retained by hills the slope of which is far from the average, and in the second instance the slider deforms the hills so much that their average slope is noticeably altered. (7) The law of friction is not applicable to a relative tangential displacement of naked metals; naked metals seize on contact and cannot be made to slide over each other in the manner of the usual friction tests.

According to the "molecular" theory, the dry friction is due to molecular or atomic attraction between the two solid surfaces. If this hypothetical attraction existed, it would have revealed itself in experiments dealing with normal separation of solids: a force additional to the weight of the slider would have been necessary to lift the slider from a horizontal surface of the support. This force does not exist. Some investigators spoke of fusion or welding between the solids as being the cause of friction. Since the coefficient of friction between wood and platinum often is as great as between two metals, the occurrence of welding is more than doubtful. In other words, the attraction theory cannot account for the observation (3) above. It also provides no explanation for the law of friction, especially for the reversibility of the coefficient of friction when the normal load is increased or decreased[21]. It does not allow an understanding of the absolute magnitude of the coefficient of friction, see observation (1) above, and is contradicted by the observations (4) and (7). When the surfaces are rough, the actual area of contact between them is likely to be small and so would be the total adhesion, that is also the coefficient of friction. When the surfaces are bare and the attraction between them can be detected and measured, then no sliding is realizable at all.

The attraction between two solids in air cannot be detected because the surfaces of the solids are covered with a layer of adsorbed oxygen (or another gas) and only the forces between oxygen and oxygen molecules are operative. These forces are very small and cannot markedly influence either the force of friction or the force required for a normal separation. Here the disagreement mentioned in the introduction as to the meaning of the word *contact* reveals itself. The adherents of the "molecular" theory believe that when a piece of metal is placed on another piece of metal in air, some metal atoms of both pieces came in a contact as close as that between two atoms within one piece of metal. The "mechanical" theory sees in such a system only contact between two adsorbed gas layers.

V. Scratching

When describing the mechanism of dry friction it was assumed that the slider climbs over the hills of the support without altering them permanently. But, if the pressure on the slider is great, these hills may be plastically deformed (squashed) or torn off, and the damage to the surface may extend even deeper than the surface asperities. Instead of friction we then have scratching.

Still, the resistance to scratching has some external similarity with the frictional force. Even if the slider is provided with a scratching point, it is still possible to measure the force required to move it along the surface of the support, to divide the value of this force by the value of the normal load and thus to compute a magnitude ("coefficient of scratching") similar to the coefficient of friction.

The former coefficient differs from the coefficient of true friction in several respects. (1) The resistance to scratching increases with normal load but this increase apparently is not as regular as that of friction; this means that the "coefficient of scratching" is independent of normal load within narrower limits than is the coefficient of friction. New experiments on this problem would be welcome. (2) The resistance to scratching strongly depends on the sharpness of the scratching tool.

[17] W. Hardy and I. Bircumshaw, *Proc. Roy. Soc.*, London, A *108*, 1 (1925).

[18] J. R. Bristow, *Proc. Roy. Soc.*, London, A *189*, 88 (1947).

[19] R. Schnurmann and E. Warlow-Davies, *Proc. Phys. Soc.*, London, *54*, 14 (1942).

[20] R. Schnurmann, *Proc. Phys. Soc.*, London, *53*, 538 (1941).

[21] J. J. Bikerman and E. K. Rideal, *Phil. Mag.*, (7), *27*, 687 (1939).

that is on the apparent area of contact; hence, the second part of the law of friction never applies to the "coefficient of scratching." (3) The "coefficient of scratching" is independent or almost independent of the roughness of the support. (4) The "coefficient of scratching" as a rule is smaller the harder the support whereas the coefficient of friction is independent of hardness.

Much confusion in the literature was produced by disregarding the essential difference between the coefficient of friction and the "coefficient of scratching." See in this connection the note by J. J. Bikerman[22].

The occurrence of scratching usually can be ascertained by a microscope study of the surface of the support. Often, scratching is accompanied by transfer of some of the material of the support onto the scratching tool or vice versa. This phenomenon was investigated using radioactive tracers by B. W. Sakmann, J. T. Burwell and J. W. Irvine[23].

Usually it can be decided whether the resistance to sliding observed is due to true friction or to scratching also without seeing the actual scratches. The above 4 points of disagreement can serve as a guide. If the ratio of tangential force to normal load depends on the curvature of the slider and the hardness of the slider and the support and does not depend on surface roughness, this ratio very probably is a "coefficient of scratching." In addition, the absolute value of this ratio is likely to be different for real friction and for scratching. If the ratio observed on a reasonably smooth surface (not a brush) is greater than one, scratching may be suspected.

VI Cutting Fluids

The resistance to scratching, cutting, abrasion and so on can be reduced by some liquids called extreme pressure lubricants, cutting oils and so on. The action of these liquids is different from that of ordinary lubricants which, in thick films, substitute shearing of liquids for friction between solids and, in smallest amounts, serve to decrease the effective roughness of solid surfaces. However, the two conditions specified for an ideal lubricant in Section 3 above seem to be satisfied also by these liquids. It appears that cutting fluids and similar agents interpose between the two solid surfaces a layer of high crushing strength and low shearing strength. This combination is achieved by using suspensions; the solid particles of the suspension jammed between the two solids can bear a higher pressure than can a liquid, but they can slide or roll along the surfaces without too much resistance. In deep drawing lubricants such suspensions are preformed; a typical deep drawing lubricant may consist of chalk powder and soap in water plus castor oil. In extreme pressure lubrication the suspension is produced *in situ* by the chemical action of the lubricant (containing chlorine, sulfur, etc.) on the metal.

The interpretation just given is yet in need of a final experimental proof. Presumably it is not exhaustive, and it seems worth while to report here briefly two additional explanations and the observations on which they are based.

Over 30 years ago L. Gurvich observed that the amount of very fine lead particles produced by a standard shaking of lead shot was greater when the shot was moistened with an alcohol than when it was moistened with benzene. Addition of 1% of oleic acid to benzene caused, on shaking, formation of as much of the highly disperse fraction as was observed when using alcohols or other "active" liquids. P. A. Rebinder and N. A. Kalinovskaya[24] studied the "Gurvich effect" for grinding metals under aqueous and non-aqueous solutions and found, e.g., that a few per cent of stearic or oleic acid increased the rate of abrasion of copper under kerosene. O. Beeck, J. W. Givens and E. C. Williams[25] similarly investigated the effect of tricresyl phosphate on the mutual abrasion of two rubbing steel surfaces. In the experiments of this type the work of abrasion, if measured at all, generally was found to be reduced by "active" compounds as represented by alcohols and fatty acids. This can formally be accounted for by the assumption that the active substances lower the interfacial tension between the solid subject to abrasion and the liquid in which the abrasion takes place. When the interfacial tension is smaller, also the work required to create a new extensive interface is smaller. The data published so far do not suffice for estimating the amount of truth in this explanation but it is advisable to bear in mind the possible effects of interfacial tension when considering the mechanism of action of cutting fluids and similar agents.

It is generally believed that cooling effect is an important part of the action of cutting fluids. However, as water has a very high heat capacity and a very high latent heat of vaporization, it seemed irrational from this point of view to add anything else to water when preparing a cutting fluid. A recent paper by N. A. Pleteneva and P. A. Rebinder[26] apparently supplies the answer to this problem. Water readily assumes the "spheroidal state." This means that water droplets placed on a hot metal plate retain their shape and float on a cushion of steam for a relatively long time before evaporation. Since they do not evaporate rapidly, they do not cool the hot plate well. Surface active compounds present in the customary cutting oils often induce spreading of water droplets and, consequently, their rapid evaporation which means also rapid cooling. This is the second additional mechanism of the action of cutting fluids.

VII. Resistance to Sliding

When a solid is made to move along the surface of another solid, the nature of the movement is quite different according to the value of the clearance between the solid, the presence or absence of a liquid within this clearance and so on. In the first six sections of this review the main mechanisms of sliding were discussed; it is clear that in actual experiments more than one mechanism may be involved simultaneously. Because these mechanisms are so different, it is essential to make sure in what region one is working. When this is not done, mistakes are almost bound to result. Such a mistake, made more than once, consists in studying resistance to scratching which is independent of roughness, calling it friction, and concluding that friction is independent of roughness.

Table II attempts to compare in a crude manner the salient features of four fundamental types of the resistance to sliding. Let the ratio of tangential force

[22] J. J. Bikerman, J. *Applied Phys.*, *14*, 436 (1943).

[23] B. W. Sakmann, J. T. Burwell and J. W. Irvine, *J. Applied Phys.*, *15*, 459 (1944).

[24] P. A. Rebinder and N. A. Kalinovskaya, *J. Phys. Chem.* (U.S.S.R.), *5*, 332 (1934).

[25] O. Beeck, J. W. Givens and E. C. Williams, *Proc. Roy. Soc.*, London, *177*, 103 (1940).

[26] N. A. Pleteneva and P. A. Rebinder, *J. Phys. Chem.* (U.S.S.R.) *20*, 973 (1946).

TABLE II.
Variation of the coefficient of sliding with increasing values of the parameter.

Parameter: Type of sliding	Normal load	Geometrical area of contact	Speed of sliding	Roughness of the solids	Hardness of the solids	Viscosity of the lubricant
Petroff	Inversely proport.	proport.	proport.	independ.	independ.	proport.
Transitional	ndepend.	independ.	almost ndepend.	little dependent	independ.	lepends
Dry friction	ndepend.	independ.	ndepend.	ncreases	independ.	.....
Scratching	lepends	lepends	?	ndepend.	depend:	.....

to normal load be denoted as the "coefficient of sliding" whatever the nature of the sliding. Generally speaking, this coefficient of sliding can depend, among other quantities, on normal load, geometrical area of contact, speed of sliding, roughness of the solid surfaces, hardness of the solids, and the viscosity of the lubricant, if present. The table shows how the coefficient of sliding varies when each of these parameters increases, for hydrodynamic lubrication between plane surfaces (Petroff), the transitional region (Section 3), dry friction (Section 4), and scratching (Section 5).

Discussion of Paper by Dr. J. J. Bikerman on "THE MECHANISM OF FRICTION AND LUBRICATION"

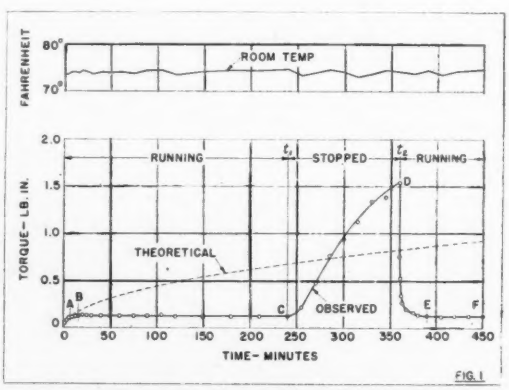
***Prepared by* S. J. NEEDS, *Service Manager*, Kingsbury Machine Works, Inc., Philadelphia**

Dr. Bikerman's paper again emphasizes the fact that our knowledge of the mechanism of friction and lubrication is not entirely satisfactory. This is particularly true when the bearing surfaces are relatively close together and the modern tendency toward increasingly heavy loads at both higher and lower speeds means operation with thinner oil films. For example, difficulty has been experienced in successfully starting some of the larger thrust bearings under heavy loads. When the bearing is not running the load squeezes most of the oil from the films and presumably the bearing surfaces come into contact, at least the high spots on the surfaces are thought to be in contact. Starting friction, therefore, is certainly in the so-called thin-film or boundary region and a better understanding of exactly what happens when the bearing is started is of the greatest practical importance. When the bearing is running and oil films have been established the bearing surfaces are relatively far apart and fluid-film or hydrodynamic lubrication is obtained. The theory for this condition has been worked out for a few cases. It is lacking perhaps in some respects but gives a good idea of what is actually going on in the films and agrees well enough with observed facts when the latter are accurately known. Unfortunately, there is no similar guide in the boundary region, nor is there likely to be, and for this reason some discrepancies exist between various theories advanced with the hope of explaining observations.

There seems to be no clear dividing line between the fields of fluid and thin-film friction. The fluid-film region cannot be limited to cases of purely viscous friction since indications of boundary influence have been found in relatively thick films. Apparently surface roughness enters the picture since this factor may determine whether a bearing will operate in the thick or thin film region. Any properly designed, well lubricated bearing will tend to have a certain film thickness. If the surfaces are extremely rough, metallic contact will occur regardless of load, speed, viscosity or clearance ratio. The bearing is then said to be overloaded and running under thin-film conditions. If the surfaces are smoothed by running in, or otherwise, the bearing will carry its load with no metallic contact and is then operating under hydrodynamic conditions. Thus, by improved surface finish fluid-film lubrication persists at thinner and thinner films, seemingly without limit. This tendency is indicated in the author's Table 1.

In Dr. Kingsbury's laboratory some years ago the surfaces of 4 in. diameter journal bearings were improved until extremely heavy loads could be carried at low speeds with complete separation of the surfaces. (1) Calculated minimum film thicknesses of the order of 5(10)-5 in. were obtained. Observed friction coefficients in the region of 0.0002, together with absence of metallic contact, seemed conclusive proof that the bearings were operating hydrodynamically. A greatly intensified viscosity was noted which was shown analytically to be due to the high pressures existing in the oil films. If viscosity was also affected by surface proximity the effect was overshadowed by the pressure influence and was not detected. The foregoing brings up the question of whether or not bearing oil films, however thin they may be, will exhibit any of the so-called thin-film phenomena if the bearing surfaces are geometrically true and smooth enough to operate without touching each other.

The source of the author's Fig. 3, gives some pertinend information on this point. The bearing was made up of two hardened toolsteel discs, optically polished and flat to better than one-millionth of an inch including the edges. The lower disc was held stationary and the upper disc rotated. Oil was placed between the discs and load applied, forcing the discs together. Torque required to restrain the lower disc from rotation was measured. Fig. 1 of this discussion shows variation of torque with time in a test with olive oil, at 11.06 rpm and a load of 100 lb. per sq. in. of disc area.



VARIATION OF TORQUE WITH TIME, FLAT DISC APPROACHING UNDER LOAD
Discs ⅞ in. diam.; load 100 lb. per sq. in; speed 11.06 r.p.m.; olive oil, 77F.; viscosity 10.1(10)-6 lb. sec. per sq. in.

Based on the bulk viscosity of the oil the torque should increase as shown by the broken line if the surfaces approach each other according to Stefan's equation. During the first eight minutes of the test, over the range OA, the observed points fall on the theoretical

[1] S. J. Needs, Trans, Am. Soc. Mech. Engrs. *60*, 347 (1938).

curve and the rate of approach seems to agree with theory. At B, however, the torque becomes constant and there is no further increase over the range BC. Apparently the film thickness has reached a minimum and approach of the surfaces has ceased. If rotation is now stopped and resumed at intervals only long enough to observe torque, it is found that the torque increases rapidly over the range CD. Resuming continuous rotation at D the torque drops rapidly at first and then more slowly until the previous constant value is reached again at E. Rotation may be continued indefinitely over the range EF and the torque will remain constant except for slight changes following room temperature. According to theory the film thickness should be 0.73 $(10)^{-6}$ in. at F. To agree with observed constant torque it should be 5.3 $(10)^{-6}$ in. Actual measurement shows it to be 32.3 $(10)^{-6}$ in. This final thickness, which apparently cannot be decreased by the load of 100 lb. per sq. in., is large compared with the surface irregularities. Microscopic examination of the surfaces showed no trace whatever of metallic contact or scratching of the polished surfaces during the test.

If rotation is stopped at any time in the constant torque region and the torque indicator moved from zero, it will return to zero immediately upon removal of the restraining force. Also at this time the torque will be found directly proportional to the speed. Apparently the film, or at least some part of it, is behaving in a purely viscous manner. Over the range CD, however, the torque bar if displaced will not return to zero and torque is no longer directly proportional to the speed. This seems to indicate that something other than viscosity has entered the picture.

The same phenomenon was observed with both vegetable and mineral oils and persisted at loads as high as 800 lb. per sq. in., the limit of the apparatus. Space limitations do not permit repetition of the detailed discussion given in the original article. It is clear, however, that there is a certain film thickness at which oil ceases to flow, even under rather heavy loads, from films formed by surfaces as described. The relatively great thickness of these residual films, as compared with the surface irregularities, makes it difficult in this case to apply Dr. Bikerman's idea of mechanical effects controling the behavior of the lubricant in thin films.

Discussion of Paper by Dr. J. J. Bikerman on "THE MECHANISM OF FRICTION AND LUBRICATION"

FRANK MORGAN

This interesting paper by Dr. Bikerman should add considerable fuel to the controversy concerning the relative importance of mechanical and molecular contributions to the friction between sliding surfaces. Although the laws of sliding friction, as we know them today, were originally based on the theory of the interlocking of asperities, it seems that in recent years the molecular component has been generally considered to be the more significant. Thus Adam appears to express the consensus of opinion in his book "The Physics and Chemistry of Surfaces" with the statement, "sliding friction is almost certainly due to the exceedingly strong adhesion between those parts of the surfaces which come into real contact with each other when two solid surfaces touch." W. F. Parish, however, in his article in the Encyclopedia Britannica is noncommital. He writes, "It is due partly to the molecular attraction between the surfaces and partly to the nature and condition of those surfaces."

Dr. Bikerman admits that he is biased in favor of the mechanical theory, but signifies his intention to present both sides of the argument in order that the reader may be in a better position to weigh the relative merits of of the two theories and judge for himself which is in better accord with experimental observations. It is not clear, therefore, why he cites the works of Wittrock and Needs which confirm his theory, while the contributions of Bulkley,[1] and Bastow and Bowden[2] are not mentioned. No anomalous viscosity effects were observed in either of the latter researches on the flow of ordinary liquids at distances from the walls of capillary tubes and discs as small as 10^{-6} inches.

In his first example, involving the region in which, in contradiction to fluid film theory, the coefficient of friction increases as the Sommerfeld variable $\left(\frac{r}{d}\right)^2 \frac{\eta v}{P}$ decreases, it is obvious that an increase of viscosity due to pressure, turbulance, rigidity, chemical reaction or any other cause could be invoked to explain the discrepancy. However, since the Sommerfeld variable is a composite function, including both velocity and pressure, the viscosity would need to possess very unusual characteristics if a single friction curve is to be obtained even for a specific journal bearing combination.

A distinction is made between the region of "thin film lubrication" which still belongs to hydrodynamic lubrication and the zone of "transition to dry friction." It appears that the dividing line between the two types may not always be sharp and well defined but the experiments of Burwell, Kaye, van Nymegen, and Morgan are listed as examples of the first class. Although a discussion of wear is beyond the scope of this paper and has not been included, it would be of considerable interest if the author would give his view of the reason for the much greater rate of wear observed for the rough surfaces than for the smooth ones during the initial periods of operation. According to the older theories the high initial wear on the rough surface might be explained on the basis of metal to metal contact due to projecting points and low load carrying capacity. When metallic contact occurs rates of wear are naturally expected to be higher than when hydrodynamic lubrication prevails.

The paper of Dr. Bikerman is particularly important in that it points to the lack of knowledge and agreement on the basic principles of friction and lubrication. In spite of modern tools and modern physical and chemical methods, progress in these fields is exceedingly slow. It is hoped that the ideas presented in the paper will be the inspiration for much fruitful research.

[1] Ronald Bulkley, *J. Res. U. S. Bur. Standards 6*, 89 (1931).
[2] S. H. Bastow and F. P. Bowden, *Proc. Roy. Soc. 151*, 220 (1935).

Comments on "THE MECHANISM OF FRICTION AND LUBRICATION" By J. J. Bikerman

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The greatest obstacle to the development of a satisfactory theory of boundary lubrication or boundary friction is the difficulty of determining in detail the

nature of the surfaces in contact. Not only must the physical characteristics of the surface, its roughness and general contour on a microscopic scale, be known, but also the nature of the ever-present contamination on the surface must be understood. Generally speaking, the surface phenomena involved are so hopelessly complex that a direct approach is practically impossible. In order to make progress, it is of course necessary to postulate various mechanisms to account for some observed frictional behavior, and to judge the satisfactoriness of such postulates by the amount of experimental material which they can explain reasonably well. However, sometimes a set of data may appear to support or disprove a given simple theory because other actually controlling factors are not taken into account because their importance is not recognized. For example, the effect of water on the lubrication of metals reported by E. D. Tingle in *Nature* for November 22, 1947 *(160,* p. 710) will certainly lead to changes in present concepts of the relationships between the chemical structure and boundary lubrication value of organic lubricants.

Mr. Bikerman's paper is an interesting exposition of various differences between the schools which emphasize either the molecular or the mechanical type of postulates. It is valuable because he emphasizes the importance of certain phenomena in the explanation of frictional bahavior. In the writer's opinion, it suffers because it omits mention of other phenomena which are equally important.

For example, one can write down the following two plausible word pictures of boundary lubrication based on what are superficially quite different pictures of the nature of the rubbing surfaces—surfaces with asperities or surfaces with rounded eminences. Neither of these explains all the observed facts, but each offers a very plausible "explanation" of lubricant behavior in terms of mobility, contaminating power and "mechanical strength."

I. Surfaces With Asperities

1. The polished metal rubbing surfaces are microscopically rough with projections and irregularities a few hundred Angstroms in extent. These asperities cover the major portions of the rubbing surfaces.

2. The presence of a lubricant cannot and does not prevent these microscopic asperities from breaking or deforming plastically to form fresh surfaces of clean metal when one bears against another.

3. When any two freshly formed and "uncontaminated" surfaces come into contact, a very strong bond is formed—practically equal in strength to that in the bulk material. Continued sliding causes further rupture of the parts so "welded," but not necessarily at the weld itself. If there is no lubricant, or if the lubricant is inadequate (see below), the process just described builds up until seizure or very serious deformation of the rubbing surfaces occurs.

4. The chief function of the lubricant is to "contaminate" the freshly exposed surface regions (resulting from the breaking of asperities) sufficiently to prevent the formation of strong bonds between two such regions of the two moving surfaces. In this way, continued severe rupture of the surfaces is prevented or limited to a definite value which does not increase catastrophically.

5. Important properties in which lubricants differ are the following:

a. Mobility—the ability to reach the freshly exposed surface areas quickly.

b. "Contaminating" power—this determines the degree of protection afforded the freshly exposed areas when they have been reached. This involves the strength of attachment of the lubricant molecule to the surface, the closeness of packing, and the area effectively "contaminated" by each molecule.

6. A "perfect" lubricant would prevent the formation of any bond whatever between freshly exposed surface areas. It would not reduce the coefficient of friction to zero, but to a value determined chiefly by the degree of microscopic roughness present. This "interlocking of asperities" kind of friction cannot be reduced by any boundary lubricant action. It should follow that the coefficient of friction with such a "perfect" lubricant would increase with the number of asperities in contact, that is, presumably with the microscopic roughness. No connection with the macroscopic roughness is to be expected.

7. Ways in which friction is produced under boundary lubricated conditions are listed below in decreasing order of importance.

a. Interlocking of asperities on the surfaces.

b. Seizure between areas freshly exposed by the breaking of asperities.

c. Actual sliding between lubricant layers separating two solid surface areas which are locally practically plane and parallel. Presumably the number of molecular layers is small, probably less than five. It seems reasonable to suppose that an appreciable part of the normal load is supported by such smooth flat regions at any instant, but it is also plausible to assume that the coefficient of friction between such regions with lubricant present is so small that they contribute little to the total friction.

d. Trapping of lubricant in localized pockets. Contacts between the rubbing surfaces occur over areas separated from each other by distances large compared with their extent. Some localized pockets will be formed, trapping the lubricant under hydrodynamic conditions. Presumably the pressure will be sufficiently high to increase greatly the viscosity of the lubricant. Even so the coefficient of friction is very small, and the probable number of trapping regions is small, so that their contribution to the total friction will be even less than that of cause (c) above.

II. Surfaces With Rounded Eminences

1. The surface irregularities on polished metal are very broad in comparison with their height. They can more fittingly be called "rounded eminences" than "asperities."

2. The presence of a lubricant prevents seizure between opposing eminences by transmitting pressure sufficiently great to press them down by a combination of elastic and plastic deformation until they pass over each other without damage. Lubricants differ widely in their ability to keep surfaces apart in this way. When lubrication is efficient, the process just described takes place in most encounters. When breaks do occur, the exposed areas travel so far before meeting others that they are very likey to become sufficiently "contaminated" by the lubricant to avoid welding.

3. When any two freshly formed and "uncontaminated" surfaces come into contact, a very strong bond is formed—practically equal in strength to that in the bulk material. Continued sliding causes further rupture of the parts so "welded," but not necessarily at the weld itself. If there is no lubricant, or if the lubricant is inadequate, the process just described builds up until seizure or very serious deformation of the rubbing surfaces occurs.

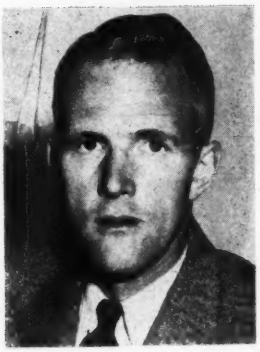
4. The lubricant has two functions: (a) to transmit

(*Continued on page* 235)

Lubricating Aerosols

By K. C. MOSIER

Chief Engineer—C. A. Norgren Co.



Mr. Mosier is a native of the State of Michigan and received his B.S. degree in Mechanical Engineering at the University of Michigan. Upon graduation, he was employed by the Ingersoll-Rand Company for several years, leaving it to enter the Armed Services. After leaving the Army, he became associated with the Aro Equipment Company as a Project Engineer in the design of pneumatic tools. Later he became associated with C. A. Norgren Company where he occupies the position of Chief Engineer.

SOME one said "Necessity is the mother of invention" and like many new developments the Norgren air-oil fog lubricator was first designed to answer a specific problem. In 1928 a certain machine involving the use of air cylinders was failing to do its job because the cylinders stuck due to improper lubrication. Almost every known method of applying lubricant was tried without success. Either too much or too little was applied with equally damaging effects. The problem was solved with the design of the first Norgren airline lubricator which utilized air flow to create a fog of air and oil and to carry it into the cylinder for continuous, automatic lubrication. Means for sight feed were provided so that the rate of oil feed could be accurately maintained. The solution of this problem witnessed the birth of a new device destined to make its mark in the field of lubrication. Even today it is impossible to analyze and predict the eventual importance of air-oil fogs, technically known as lubricating aerosols, although it is now realized that in a large measure this method of lubrication is as separate and distinct from oil, as oil is from grease. It is, therefore, the purpose of this article to report what has been done in the past with lubricating aerosols and to perhaps point to new fields.

Following the application of this principle to compressed air cylinders, efforts were made to lubricate pneumatic tools by placing a lubricator in the air hose. Since this attempt was made prior to the use of oil resistant cores in air hose, trouble was experienced from the deterioration of the hose. However, the advantage of using lubricating aerosols for pneumatic tools was so apparent that the desire to use the idea for the purpose was one of the principal reasons for the development of oil resistant core air hose.

This wide field of application was responsible for the gradual acceptance by industry of the principle of lubricating aerosols. It remained for certain imaginative individuals to broaden the concept of its usefulness from one of lubrication as an auxiliary to the use of compressed air power to one in which the air and oil form an aerosol with exclusive and fundamental properties of value in the general field of lubrication. For example, in 1936, the demand for grinding speeds created a problem in lubrication of the bearings carrying the spindle. C. W. Bidwell of the Fafnir Bearing Corp. became interested in the possibility of using lubricating aerosols for high speed spindle bearings and was responsible for some of the very first tests on the Norgren lubricator for that purpose. It is also interesting to note that concurrent with the work of Bidwell at Fafnir, engineers at the Bryant Chucking Grinder Company began independently experimenting with lubricating aerosols for high speed grinding spindles. At about this same time the SKF Company also became interested in the subject. Credit for the development of present-day technique of lubricating aerosols for high speed bearings belongs to all of the gentlemen concerned with this early work.

What was considered high speed in 1936 is slow today and with the upward trend of speeds, it has been necessary to constantly improve the quality of the lubricating aerosol and the performance of the device producing it. From the original all-purpose Norgren airline lubricator used by the pioneers for the lubrication of high speed spindle bearings has evolved the present modern unit which includes a pressure regulator and special air filter for conditioning the compressed air. It is specially designed for production of lubricating aerosols. Figure 1 illustrates the application of this latest type unit to a modern grinding machine operating at about 100,000 RPM. The unit is shown at the right and center of the figure. Other applications have proven successful at even higher speeds, and it is well to note the reasons why lubricating aerosols will successfully lubricate high speed grinding spindles. They are:

1—The air portion of the lubricating aerosol provides a cooling medium which maintains uniform spindle temperature for greater accuracy.

2.—By permitting the aerosol to continue flowing for a short time after shutdown, the creation of a partial vacuum within the spindle housing as it cools down is avoided, and harmful grit will not be drawn into the housing.

3—The micronic particles of oil penetrate the hard core of air surrounding the rapidly rotating bearing to lubricate it without causing uneven rotation. In this respect, it has been established that certain types of aerosols readily wet the surfaces against which they impinge while certain other types do not. Only a wetting type aerosol provides lubrication and any definition of a lubri-

cating aerosol must include that requirement. Since one of its characteristics is the ability to wet surfaces, it follows that there will be some condensation in the pipeline leading to the spindle and the lubricator must be mounted as close to the spindle as possible. Aerosols which can be transmitted some distance without considerable condensation of oil within the line are not lubricating aerosols, since it is obvious that they do not readily wet.

4—Only new oil is ever carried to the surfaces of the bearing.

5—Air pressure slightly above atmospheric is maintained inside of the spindle housing to prevent entrance through the labyrinths of foreign matter such as abrasives and coolants.

Following the successful use of lubricating aerosols for high speed grinding spindle bearings, attempts were made to solve other difficult lubrication problems with this new medium. In many cases the problem had defied solution by conventional methods and lubrication aerosols were tried as a last resort. Very little was known about the characteristics of lubricating aerosols and even less about how to best apply them for various uses. Although each new successful application represented a gain in knowledge, it remained necessary to consider the exact operating conditions in each case and to proceed on a careful trial and error basis. More is known about the application of lubricating aerosols today, but it is still advisable to proceed on much the same basis and for that reason the following successful applications are hereafter presented on a factual basis so that they may be used in evaluating the possibilities of lubricating aerosols for still other applications. Incidentally, it will be noted that some of these fall under the category of cutting fluids rather than lubrication. No attempt has been made at this writing to differentiate between the two general fields as concerns the use of lubricating aerosols.

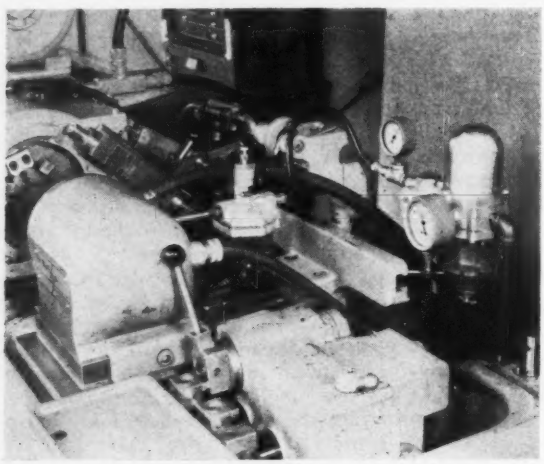


Fig. 1 Installation of Lubricating Aerosol Unit on High Speed Grinding Machine

(Courtesy Bryant Chucking Grinder Company)

Case 1 is a machine for finishing railroad journal bearings after they have been re-babbitted. A fly cutter turning at 3400 RPM is held stationery while the bearing passes across it. Depth of cut is 3/16" to ¼". Prior to the use of aerosols two cuts were necessary to obtain the required finish. With lubricating aerosols as a coolant, a smooth-surfaced finished bearing was obtainable with one cut. The tube applying the aerosol is mounted directly in front of the fly cutter. A button valve is actuated by a cam mounted on the front carriage so that the lubricating aerosol is automatically turned on and off. Credit for this application belongs to the Magnus Metal Division of National Lead Company.

Case 2 covers a Do-All metal-cutting bandsaw with attachment for application of a lubricating aerosol to the blade. The aerosol is supplied through a head which has a blade slot with small orifices on each side. Compare Fig. 2 with Fig. 3 to realize the value of lubricating aerosols for cutting #17ST aluminum. Fig. 2 shows the fourth cut of a 6" bar with a new blade without lubrication and Fig. 3 shows the 105th cut with a new blade with aerosol lubrication. In this application the jet of air impinging on the teeth prior to entrance into the bar is also of value in removing chips. Continental Machines, Inc. (makers of Do-All saws) is responsible for this development.

Case 3 is the application of a lubricating aerosol to the machining of a cast aluminum sheave. Incidentally, in applications of this nature, some condensation of the aerosol is permissible in the line leading to the cutting tool, hence longer transmission is possible than in the case of high speed spindle bearings. Credit belongs to Utility Appliance Corp., Los Angeles.

Case 4 is the application of lubricating aerosols to a tapping operation. Similar installations have been made on drilling operations. Fig 4 shows a close-up of the installation. On the outlet of the lubricator is an aerosol distributor which divides the aerosol evenly into as many as sixteen different circuits. Each such circuit terminates in a small jet for raising the velocity with which the air impinges on the tap. Operation is controlled by means of a solenoid air valve energized on the motor reverse circuit. As the tap is withdrawn, it is therefore cleaned and lubricated. The aerosol distributor shown in these photographs was specially developed to proportion the aerosol since the eccentricities of compressible fluid flow in pipe lines are such that without the distributor, unform distribution is impossible. The design of the distributor was also influenced by frequent requirements for intermittent flow. Even in cases of distribution into two lines, a streamline wye is recommended. The W. F. and John Barnes Corp. are responsible for this important application.

Last but by no means least is Case 5 covering the application of a lubricating aerosol to drawing and stamping operations. An elementary application on deep drawing was originally made by simply bending copper tubing so as to direct the aerosol onto the surfaces of the die. Operation was made automatic by means of a blow valve mounted on the machine frame and actuated by the ram. Later installations were made with dies designed for this type lubrication in which ports were drilled into the die itself, permiting application of the aerosol at the necessary internal points. In such cases an aerosol distributor is used to advantage. The possibilities for application of lubricating aerosols in this field are tremendous since as much labor is now used to "butter" the drawing blanks as that required to perform the actual drawing operation. *Think of it—cutting labor costs in two.* One obstacle to be overcome in many cases is the insistance on a certain drawing compound since many plants have developed their own. Most of these compounds are of relatively high viscosity and specially designed lubri-

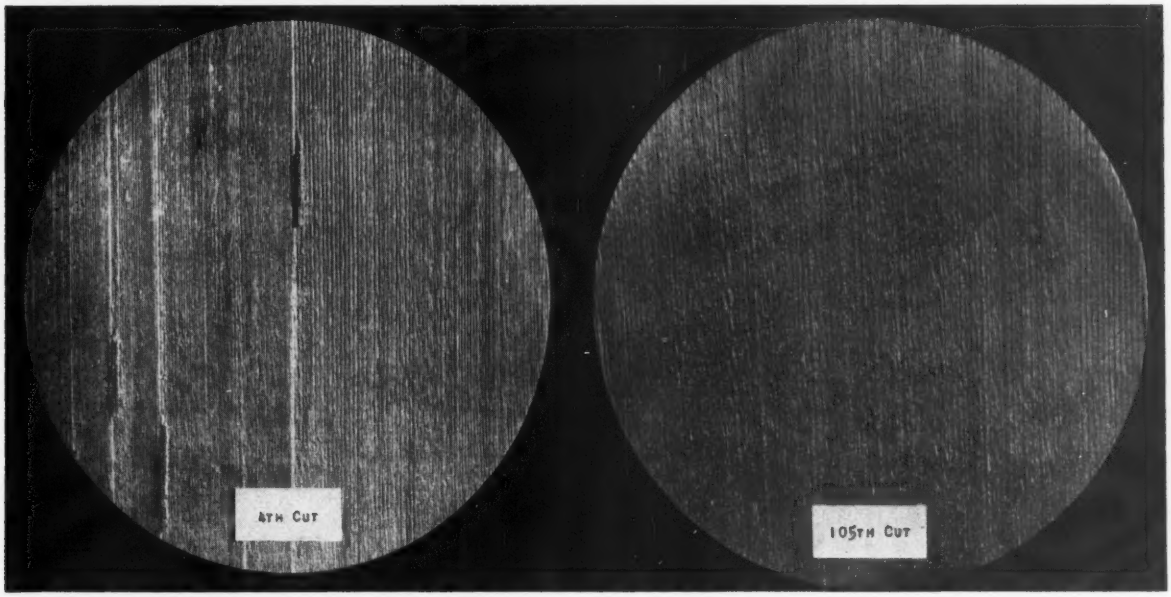


Fig. 2 4th Cut in Aluminum Bar by Saw Using New Blade Without Lubrication
(Courtesy Continental Machines, Inc.)

Fig. 3 105th Cut in Aluminum Bar from an Originally New Blade Using Lubricating Aerosol
(Courtesy Continental Machines, Inc.)

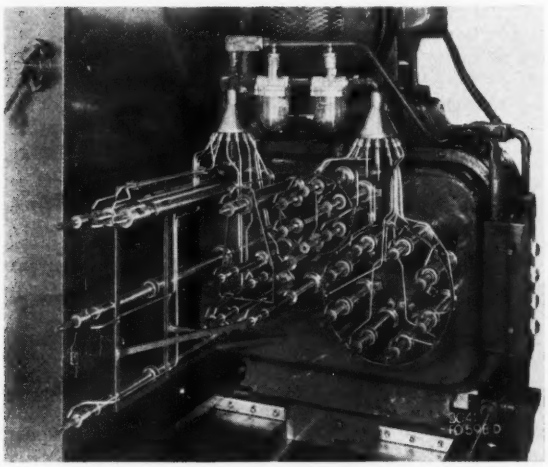


Fig. 4 Close-Up Showing Installation of Aerosol Lubrication on Multiple Tapping Machine
(Courtesy W. F. and John Barnes Company)

cators may be required although oftentimes the die slick can be thinned. The possibility of using liquid neutral detergents which can be applied as an aerosol to lubricate the drawing operating and yet permit painting of the part without degreasing removes another major objection to this method. Although the field of stamping and drawing would seem to offer the greatest reward in conservation of labor, it is strange to note that relatively little work has been done here as compared to other fields with less obvious advantages.

Space does not permit a complete resume of the story of lubricating aerosols. Most of the foregoing applications have been concerned with soft metals such as aluminum. However, successful installations on cutting and drilling operations of steel, plastics, etc., have been made. In applying lubricating aerosols certain disadvantages such as the possibility of dissipating too much of the aerosol into the atmosphere and a limitation on the maximum heat load must be considered. By taking these disadvantages into consideration in making the installation, success is often assured. It is obvious that a great many more applications of aerosol lubrication are possible, and it is hoped that this brief description may serve as the spark for the development of others.

Performance of Silicone Lubricants at High Temperatures*

By C. C. CURRIE

Dow Corning Corporation

SILICONE fluids and greases are ideally adapted to use as high-temperature lubricants because of their unique resistance to oxidation and thermal decomposition. All silicones are built on an inherently stable framework of alternate silicon and oxygen atoms modified by the addition of one or more organic groups to each silicon atom. The silicones are, therefore, semi-inorganic materials possessing much of the stability of glass and the other mineral silicates together with the water repellency and ease of handling usually associated only with organic materials.

By varying the organic groups attached to the silicon atoms, such physical properties as viscosity index, lubricity and pour point may be altered. The size of the molecule can also be controlled to affect such properties as flash point, volatility, and intrinsic viscosity.

The first class of silicone lubricants to be considered are the fluids. These crystal clear materials are produced in a wide variety of types and viscosities. They are, however, all characterized by a high degree of heat and oxidation stability; incompatibility with water and many organic solvents; chemical inertness and relatively flat viscosity temperature slopes. Silicone fluids have good lubricity under light to medium loads and meet most of the requirements for permanent lubricants for use at abnormally high and low temperatures.

DC 710 Silicone Oil

DC 710 silicone fluid was developed for general lubrication at temperatures above the range of most organic lubricants. It remains liquid down to 10 F and is serviceable at temperatures up to and exceeding 500 F. At normal temperatures and under light to medium loads DC 710 in a viscosity of 500 centistokes compares favorably in lubricity with good petroleum oil of the same viscosity. It is superior, however, at elevated temperatures because of its low volatility, high flash point and freedom from gumming.

One of the devices used to determine the relative lubricity and service life of DC 710 reproduces conditions found in many conveyor systems. In this device bicycle chains are cycled through an oven at 350 F for 80 minutes, through atmospheric temperature for 40 minutes, through a 100% humidity cabinet for 80 minutes and back through room temperature to the oven. Chains lubricated once with DC 710 oil containing a rust inhibitor remained operable under these conditions for more than 500 days. Chains lubricated with organic oils specially compounded for oven conveyor systems remained operable only 35 days before the chains rusted and the roller bearings seized.

It is common knowledge among lubrication engineers that highly refined petroleum oils possess no rust inhibitory properties. DC 710 silicone fluid is similar in this respect and for that reason it is available as 3C 710R with an effective rust inhibitor added. Another modification of DC 710 contains colloidal graphite in suspension and is called DC 710G. Both DC 710R and DC 710G have proved their usefulness under the most severe operating conditions.

One such application involves the bearings used in a brake block oven conveyor in the plant of a large automotive parts manufacturer. The conveyor which operates at 400 F was formerly lubricated twice a week with a graphited petroleum oil. Even with such frequent lubrication about 30 dollys had to be replaced every week because of seizure of the bearings.

Eleven months ago the conveyor system was completely lubricated with DC 710G. The conveyor has now been lubricated with DC 710G five times at intervals varying from 6 to 13 weeks. Not one dolly has had to be replaced. Some of the dollys that had already started to stick when the change was made have loosened up and are now in excellent shape.

During the eleven-month period a gradual accumulation of graphite in the bearings has been noted. DC 710R is used to reduce the build-up by redistributing the graphite. This situation is analogous to that encountered with the use of DC 41 silicone grease discussed in detail in another section of this paper.

DC 550 Silicone Oil

DC 550 type silicone oil is available in a viscosity grade of 100 to 150 centistokes for use where a lubricant less viscous than DC 710 is desired. DC 550 remains serviceable at temperatures ranging from —54 F to 300 F and upward. The fact that it does not gum or gel when held at 482 F for 1,000 hours demonstrates the remarkable heat stability of this silicone oil. Although DC 550 is a good lubricant for hardened steel under light to medium loads, it is not recommended for use where one surface is either cast iron or soft steel. DC 550 has found considerable use as a permanent lubricant in oven timers, clocks, and other delicate mechanisms where bronze bushings are used.

DC 200 Silicone Oil

The DC 200 fluids are available in viscosity grades ranging from 0.65 to greater than 30,000 centistokes. All of the DC 200 fluids show exceptionally small changes in viscosity over a wide temperature span. This relatively constant viscosity plus high flash and fire points and low volatility, indicate the usefulness of DC 200 fluids in damping, lubricating and hydraulic applications.

J. E. Brophy and co-workers[1] have found that DC 200 silicone oil is a satisfactory journal bearing lubricant at temperatures in the range of 300 F to 375 F. Their investigations showed that DC 200 fluid could be used for long periods of time at such temperatures without

* Presented before the Chicago Section of A.S.L.E., May, 1948.

[1] High Temperature Performance of Silicone Fluids in Journal Bearings, J. E. Brophy, J. Larson, R. O. Militz. Presented at the A.S.M.E. December, 1947, meeting.

significant deterioration provided that the bearings were properly broken in. At 145 F the load-carrying capacity of the silicone fluid was found to be greater than 3 times that of a non-additive petroleum oil of the same viscosity. A chromium plated journal was rotated against bronze bearings of 89% copper, 4% tin, 4% lead, and 3% zinc in these tests.

The data presented by Brophy et al is substantiated by our own laboratory work with a Falex lubricant machine. DC 200 was found equal in lubricity to petroleum oils at normal temperatures and was superior to petroleum oils at elevated temperatures for metal combinations other than ferrous against ferrous surfaces.

In addition to the silicone fluids adready described several silicone grease lubricants for high temperature lubrication have also been developed. These are described below.

DC 41 Silicone Grease

DC 41, the first silicone lubricating grease developed for high temperature use, is made by thickening a silicone oil with a special grade of carbon black. DC 41 has a worked penetration of 260-300 and shows extraordinary resistance to oxidation and thermal decomposition. It has no true dropping point in that no melting occurs even at temperatures in excess of 400 F. DC 41 has found widespread use as a lubricant for oven conveyor bearings and other anti-friction bearings at speeds up to 4,000 rpm and at temperatures of 400 F and upward, because it has a long lubricating life and does not melt or run at high temperatures. Continuous exposure to temperatures in the range of 375 F has little or no effect on DC 41 silicone grease, but prolonged exposure to temperatures above 375 F may eventually cause some slight thickening.

The most satisfactory way to use DC 41 at temperatures of 400 F to 500 F depends upon the kind of bearings. Open type ball and roller bearings are lubricated with DC 41 at one to four week intervals, although there are instances where lubrication is even less frequent. Sealed bearings are originally packed with DC 41 and at intervals of one to four weeks freshened by the addition of a few drops of DC 710R silicone oil. After several oilings with DC 710R, the bearings are greased with DC 41 and the cycle is repeated.

DC 41 has proved to be most useful at temperatures ranging from 250F to 700F in bearings exposed to corrosive atmospheres. In one case an automobile manufacturer was troubled with an almost constant maintenance and lubrication problem when operating a monorail paint conveyor handling body parts and fenders. The parts were hung on hooks "in the white," run through a paint spray booth, air dried, and then cured or baked in an oven at 450 F.

Several special high temperature organic lubricants and several different lubrication techniques were tried with little success in an attempt to keep the conveyor operating. Occasionally steel links were actually broken by the seizure of bearings gummed up with carbonized grease. When the conveyor was shut down for a day or two, the combined pull of 10 or 15 men was required to start it again even with the power on full.

DC 41 silicone grease solved this very difficult lubrication problem. The bearings are now lubricated every three months with DC 41. A few drops of DC 710R are added once a month to freshen the grease. Manual starting, seized bearings, and broken connecting links have been entirely eliminated.

Mr. Currie received a Bachelor of Science Degree from Alma College in 1939. Shortly after his graduation he started work as a chemist for the Ethocel Division of The Dow Chemical Company in Midland, Michigan. He became associated with the basic research group in silicone chemistry maintained by The Dow Chemical Company, shortly after the group was organized. As a member of that group Mr. Currie has cooperated in the writing of many technical papers and has been granted various patents. About a year ago Mr. Currie was placed in charge of the Product Development group maintained by Dow Corning Corporation to work on silicone fluids and lubricants.

In another automobile plant DC 41 is used to lubricate six conveyor systems that transport engine cylinder block cores and engine head cores through the core ovens by overhead trolleys. Each system includes four six inch roller bearings mounted in the oven and 1200 trolley bearings.

The conveyors are in operation 16 hours a day, five days a week. A complete cycle totals 4 hours of which $2\frac{1}{2}$ hours are spent in the core oven at a peak temperature of 700F. All the various organic lubricants including a suspension of graphite in kerosene involved continuous lubrication of the trolleys and weekly cleaning and lubrication of the large six inch roller bearings. Even so, the trolley bearings frequently froze and the trolley wheels dragged and became flat. Now the trolley bearings are greased only once a week and the large roller bearings are lubricated once every two weeks with DC 41 silicone grease. All seizing has been eliminated and the individual conveyors require only about one-ninth as much power.

DC 41 silicone grease is used to lubricate sealed bearings conveying parts through alkali, Bonderite, chromic acid spray chambers, paint spray booths, and high temperature ovens. It has also been used successfully in the roller bearing casters of oven carts loaded with 1000 to 2000 pounds. Although the carts are wheeled into a 325F oven for 4 hour periods several times a day, DC 41 remains serviceable for two to three months. These bearings were previously relubricated every few days with a high grade organic grease.

When using either DC 41 or DC 710G in sealed bearings care must be taken to prevent excessive buildup of carbon or graphite in the bearings. A few drops of DC 710R will prevent the buildup from reaching a dangerous point. The importance of limiting the buildup cannot be over emphasized.

DC 44 Silicone Grease

Silicone electrical insulation, made up of inorganic materials such as glass, asbestos, and mica bonded and impregnated with silicone insulating resins and varnishes, permits electric motors to operate at temperatures 200F

above the limits of Class "B" insulation. At such operating temperatures the service life of even the best hydrocarbon lubricants is severely limited. The obvious solution was a silicone grease for the bearings of high temperature silicone insulated motors.

DC 44[2] silicone grease was developed for such applications as well as for the lubrication of antifriction bearings operating at speeds up to 20,000 rpm and at temperatures ranging from—40F to 350F. Within this temperature range DC 44 is practically non-volatile and highly resistant to hardening.

In the course of developing various silicone greases, an extensive test program was set up to evaluate formulations and to compare them with conventional organic greases. Much of the data collected on the life of DC 44 silicone grease at elevated temperatures is very conservative because most of the testing was done in bearings that had not been stabilized for high temperature operation. Life of the organic greases is in general less affected by this factor than that of the more heat-stable silicone greases. Tests show that in bearings not stabilized for high temperature operation, the life of DC 44 silicone grease at temperatures in the order of 300F is about 10 times the life of the high temperature petroleum grease tested in the same fixtures.

One test unit for direct performance evaluation consists of six No. 212 ball bearings mounted on a shaft spring-loaded with 150 pounds radial load. The unit is enclosed in a housing that can be heated to any desired temperature. When tested in this device as a lubricant for bearings not stabilized for high temperature operation, DC 44 silicone grease had a life of 3000 hours at 257F, 2600 hours at 302F and 450 hours at 392F. High temperature petroleum greases averaged 200-300 hours at 302F in the same tester.

A second test unit consists of two No. 204 bearings in heated housings, mounted on a belt-driven shaft revolving at 10,000 rpm. Bearing failures are indicated by changes in torque as measured by temperature rise and also by changes in hot and cold coasting times. In this test DC 44 had a life of 6500 hours at 257F and 2600 hours at 302F in bearings that were not stabilized for high temperature operation. Organic greases failed after only 720 hours at 257F.

DC 44 has also been tested in the bearings of silicone insulated electric motors. The load on these silicone insulated motors rated at 7½ hp, 1750 rpm, 440 volts can be varied through belt driven generators to give bearing temperatures in the range of 300F to 400F. Tests indicate that bearings lubricated with DC 44 have a service life of at least a year at 240F to 260F. An exact figure cannot be given because there is still no sign of bearing failure in that temperature range. DC 44 has a life expectancy of approximately 2500 hours at 302F.

Few of the known applications for this silicone grease involve temperatures above 300F. In most cases, DC 44 is used because of its very long lubricating life at temperatures in the range of 200F to 300F.

In sealed bearings operating at temperatures in the range of 150-250F, DC 44 silicone grease may be expected to give relatively permanent lubrication. Sealed bearings packed with DC 44 silicone grease are now standard equipment on electric motors designed to give long service at high temperatures.

DC 33 Silicone Grease

A third silicone grease known as DC 33[2] has been developed for anti-friction bearings that are exposed to very wide variations in operating temperatures. DC 33 silicone grease is serviceable at temperatures ranging from —100F to 300F and at speeds up to 20,000 rpm. It is also very resistant to outdoor weathering. Some of the principal applications for DC 33 are in the aircraft industry.

Other Silicone Lubricants

Several special purpose silicone compounds and greases have also been developed. Among them is DC Valve Seal A, a silicone material designed for sealing and lubricating pressure lubricated valves and flow meters. DC Valve Seal A is a translucent and non-melting compound useful at temperatures from —40F to 400F. Its consistency is relatively constant over a wide temperature range. It is insoluble in water, resistant to steam and chemically inert. These properties have resulted in a considerable use of DC Valve Seal in chemical plants where a wide variety of corrosive materials are encountered.

Summary

Silicone lubricants in the form of oils and greases are available for high temperature lubrication. DC 710 in the viscosity of 500 centistokes is the most heat resistant of the silicone fluids. DC 710R is most useful as an auxiliary lubricant or freshening agent for DC 41 or DC 710G. The largest use for DC 710G is in lubricating oven conveyors or mechanisms where very high temperatures are encountered.

DC 550 fluid in a viscosity of 100 to 150 centistokes also possesses good heat resistance and is available with either a rust inhibitor or colloidal graphite added.

Contrary to earlier findings, DC 200 is an excellent lubricant for certain metal combinations. It is produced in a wide range of viscosities and has a lower viscosity temperature slope than any silicone or hydrocarbon oil.

DC 41 and DC 44 silicone greases are high temperature bearing lubricants. Considerable use for DC 41 has been found in the field of conveyor lubrication . DC 44 silicone grease is widely used in antifriction bearings for electric motors operating at high temperatures. It more nearly approaches the concept of a permanent lubricant for sealed bearings than any other lubricant now known.

DC 33 and DC Valve Seal A are silicone greases designed for special applications. DC 33 is resistant to extreme variations in temperature while Valve Seal A has established its usefulness in pressure lubricating valve and flow meters where heat and chemical corrosion are factors influencing service life.

In conclusion, one point should be made clear. Although silicone oils and greases are exceptionally well suited for many applications in the field of extremely high and extremely low temperature lubrication, they were developed for specific uses and are not intended for use where an organic lubricant is satisfactory.

[2] DC 44 and DC 33 are both produced in these consistencies:

Consistency	*Worked Penetration*
1. Fluid	380
2. Light	300-320
3. Medium	250-270
4. Heavy	200-220

CURRENT LITERATURE

Chemical and Engineering News, Vol. XXVI, No. 29, July 19, 1948

FUTURE LIQUID FUELS
Gunness, R. C.—pp. 2123-2127,2171

The demand for petroleum products, which has quadrupled during the past 25 years, is expected to increase another 30% by 1970. Domestic crude oil production, some foreign imports and synthesis from natural gas and coal can meet the need. The quanity and quality of future liquefied fuels and the significance of the Fischer-Tropsch synthetic fuel process are discussed.

GE SILICONE PLANT COMPLETED
Anon.—p. 2131

The multimillion dollar chemical plant built by the General Electric Co. for the manufacture of silicone materials is now in full operation, producing silicone rubber, oils, greases, resins, and water repellents. The plant is located at Waterford, N. Y. Five illustrations are presented.

API ANNOUNCES VISCOSITY STANDARDS
Anon.—pp. 2146

The American Petroleum Institute announces that restandardization of the three API viscosity standards has been completed. The standards are available for calibration of both kinematic and Saybolt viscosimeters. The approximate viscosities of the viscosity standards are tabulated.

Chemical Engineering, Vol. LV, No. 7, July, 1948

CHEMICAL PETROCHEMICALS
Hightower, J. V.—pp. 105-107
PETROCHEMICALS
Anon.—pp. 136-139

Rapid growth, since 1945, of the Bishop, Tex., plant of the Chemical Division of Celanese Corp. of America symbolizes the remarkable expansion of the petrochemicals. The Bishop plant—Chemcel is its name—is one of the leading manufacturers of chemicals from petroleum. Last year new units for manufacture of isopropyl alcohol, n-propyl alcohol and butyl alcohols came into operation. The 1948 prospect is for further expansion. Estimates of the total plant investment range between $20-$25 million. Chemcel employs around 900. This includes a technological staff of about 60. Chemcel produces, at present, the following finished chemicals: acetic acid, acetaldehyde, acetone, butyl alcohols, formaldehyde, isopropyl alcohol, methylal, methanol and n-propyl alcohol. On pp. 137-139 a flowsheet is given for the production of petrochemicals from propane and butane. Hydrocarbons are compressed and oxidized (partial oxidation). Gaseous products are cooled and valuable chemicals scrubbed out with water.

BLENDER EFFIENCY
Beaudry, J. P.—pp. 112-113

Complicated mathematical derivation leads to simple formulas that show how well a blender is operating.

SILICONES
McHard, J. A.—pp. 228, 230, 232, 234

Typical samples of several commercially available silicone products were tested according to A.S.T.M. D 543-43 to determine their resistance to 10 percent, 30 percent, and concentrated sulfuric acid at room temperature and at 100 deg. C. Changes in viscosity were taken as a measure of the resistance of silicone fluids to various concentrations of sulfuric acid. Silicone products, with the exception of certain silicone rubber stocks, have good resistance to dilute sulfuric acid at room temperature and at 100 deg. C., and poor resistance to concentrated sulfuric acid. Two silicone greases were designed for use where chemical resistance is most important. Both were serviceable for valve handling 10 and 30% sulfuric acid. Table III shows results with silastic. Table II shows results for silicone resins.

THE DECLINE OF COAL-BASED CHEMICALS
Weiss, J. M.—p. 268
(American Institute of Chemical Engineers, Cleveland, May 12, 1948

The day of expansion of the organic chemical industry based on coke-oven naphthalene and benzene has reached the twilight stage. Further substantial growth depends on new sources of supply, either from petroleum or by the treatment of coal in new ways. Steel and coke oven operations reached a peak in 1929 which was only exceeded in the war period of 1940-1944, with a sharp drop in 1945-46 due to the coal and steel strikes and renewed upward trend in 1947. It will be of great interest to watch new developments in coal treatment and in coal byproducts which may extend the field of industrial organic chemistry on the basis of raw materials at a price low enough to encourage such developments. Unless such develop, coal-based products seem fated to be of steadily decreasing importance in the field of synthetic organics with greater and greater emphasis on products based on petroleum or natural gas.

Chemical Engineering Progress, Vol. XLIV, No. 7, July, 1948

INTRODUCTION TO FLUIDIZATION
Leva, M., Grummer, M., Weintraub, M., & Pollchik, M.—pp. 511-520

Counter-gravity flow of air, carbon dioxide, and helium through beds of round and sharp sands have been investigated. This type of flow does not differ fundamentally from cogravity flow provided no bed expansion occurs. The importance of the point of bed expansion in connection with the onset of fluidization was understood and a correlation was developed which will permit the estimation of the fluid rate necessary for initial bed expansion. The proposed equation applies to narrow cuts as well as mixtures, provided the diameter of the particles in the mixture is defined according to the rule proposed in the paper. Typical photographs of the materials tested are presented. Fluidization phenomena in a 2½ and 4-inch glass tube are discussed and possible explanations for the slugging and channeling behavior of fluidized beds are proposed.

SIMPLIFIED PRESSURE-LOSS CALCULATIONS FOR PLASTIC FLOW
McMillen, E. L.—pp. 537-546

Vol. XLIV, No. 8, August, 1948

FRACTIONAL DISTILLATION OF MULTICOMPONENT MIXTURES
Underwood, A. J. V.—pp. 603-614

A rigorous analytical method is presented for making fractionating column calculations for multicomponent mixtures, constant molal reflux and constant relative volatilities being assumed. The method for determining the minimum reflux ratio, which has been presented previously (see J. Inst. Petroleum, Vol. XXXI, 1945, pp. 111-118, and Vol. XXXII, 1946, pp. 598-613 and 614-626) is further extended and applied to cases where there is one or more distributed components. The paper was presented at Fortieth Annual Meeting of the American Inst. of Chemical Engineers, Detroit, Mich. On pp. 613-614 the reader will find the discussion of the paper.

EFFECTIVE ABSORPTION AND STRIPPING FACTORS FOR MULTICOMPONENT FRACTIONATION CALCULATION
Edmister, W. C.—pp. 615-618

Recently the writer proposed a new method of making theoretical plate and component distribution calculations for multicomponent fractionation. This new method consisted of overall equations for each section, i.e., enriching and stripping. (See Trans. Am. Inst. Chem. Engrs., Vol. XLII, 1946, No. 1, p. 15, No. 2, p. 403, and No. 4, p. 757). In the present article the author proposes a shortcut procedure, either corrected or uncorrected, which may be used for preliminary calculations in preparation for more detailed plate-to-plate calculations.

Chemical Industries, Vol. LXIII, No. 1, July, 1948

SUBLIMATION: ITS APPLICATIONS IN CHEMICAL PROCESSING
Wilke, C. R.—pp. 34-38, 122, 124, 126, 128

Sublimation figures importantly in several modern chemical processes, but there is much need for more fundamental data necessary to accurate design of equipment.

PHYSICAL TECHNIQUES FURTHER MODERN ORGANIC RESEARCH
Anon.—pp. 48-49

The techniques of physical chemistry, utilizing precise measurements to study the character of organic reactions, are extending fundamental knowledge, improving processes. Bennett et al, reviewed the evidence pointing to the existence, in mixed nitrating acid, of the ionic species No. 2 . The ultraviolet absorption, for example, was different from that of free nitric acid or of nitrate ion. The vapor pressure of the solution is lower than would be expected in the presence of nitric acid or nitrogen pentoxide. n-butane doesn't isomerize, but as little as 0.01 per cent of n-butane was enough to get the rearrangement under way. What happens to the peroxide in peroxide-catalyzed polymerizations? Barlett and Altschul attacked this problem by using chlorobenzoyl peroxide (rather than the more common benzoyl peroxide, since the chlorine can be followed more easily) to catalyze the polymerization of allyl acetate. Most (72 per cent) of it, they learned, landed in the end-groups of polymer molecules.

SHELL BUILDS SYNTHETIC DETERGENTS PLANT.
Anon.—p. 111

The first unit in what may become a complete plant for making oil-derived synthetic detergents used in household and industrial soaps, cleansers and emulsifying agents is being constructed by the Shell Chemical Corp. in Wood River, Illinois. A subsidiary of Shell Oil Company, Inc., Shell Chemical will process raw materials received from Shell Oil's refinery in Wood River, near St. Louis. The new unit is scheduled to

(*Continued on page* 237)

NEWS OF INDUSTRY AND PERSONNEL

News From Paris

Our office was very pleased to receive a communication from the Institut du Pétrole des Carburants et Lubrifiants in Paris. Along with the letter, which was written by Monsieur J. Groff, Chief of the Department of Lubricants, and a member of A.S.L.E., was sent a copy of the book which the Institut has published, entitled "Lubrifiants et Graissage." He points out the interesting fact that this was printed clandestinely during the War period. Monsieur Groff extends a cordial invitation for any members of the A.S.L.E. who are visiting in Paris to visit the Institut. The Society is very glad to have messages from overseas friends with mutual interests.

Tichvinsky at U. of Cal.

Appointment of Leonid M. Tichvinsky to Professorship in the Dept. of Mechanical Engineering, University of California, Berkely, Cal., has been announced by Dr. R. G. Sproul, President of the University, August 27, 1948. Professor Tichvinsky's duties, besides undergraduate courses on Internal Combustion Engines and Lubrication, will include post graduate courses on the Hydrodynamic Theory of Lubrication. Professor Tichvinsky was formerly Associate Professor in the Dept. of Mechanical Engineering, Washington University, St. Louis, Missouri. He is the past (1947-1948) Chairman of the St. Louis Section of the A.S.L.E.

NEW SWIFT PLANT

Operations will begin this fall in a new Industrial Oil processing plant at Hammond, Indiana, that will add new sources of glycerides and fatty acids to the industrial oil production of Swift & Company, according to E. A. Moss, vice president.

The new plant is located on part of a 70-acre tract at 165th Street and Indianapolis Boulevard. Eight buildings and a tank farm are included in the construction.

This new construction will include units to carry out three processes, namely, solvent crystalization, solvent fractionation, and fat splitting.

By these processes, Swift & Company will produce improved industrial oil products of uniformity in quality, and in quantities sufficient to fill the requirements of mass production industries. At the same time, the company can more fully utilize the raw materials available from its many plants.

Products from the plant will provide raw materials to industries that manufacture such items as cosmetics and toilet creams, soaps, floor waxes and polish, linoleum, phonograph records, candles, shoe polish, rubber products, paint, textiles, wallpaper, printing inks, cleaning and waterproofing agents, leather dressing, buffing and lubricating compounds, wire drawing compounds, insecticides and cutting oil.

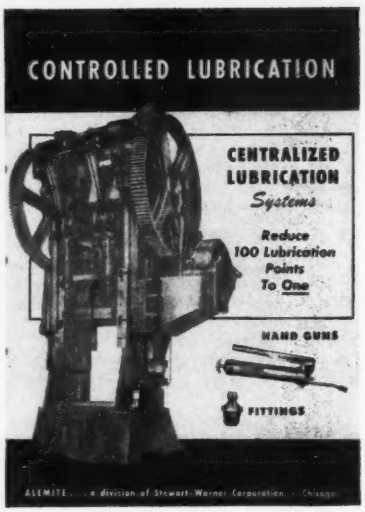
Research into new and improved products and new uses for these products will be a vital part of the new operation and will be carried on in an experimental pilot plant. Research also will continue in Swift & Company's central research laboratories.

The present production of industrial oil by Swift & Company is obtained almost entirely from glycerides of animal origin. However, the new Hammond plant will also allow volume production of glycerides and fatty acids from vegetable and marine oils.

NEW ALEMITE CATALOGUE

A new catalog presenting Alemite's four basic systems of centralized lubrication is now available to industry through Alemite distributors and jobbers, Gus Treffeisen, distributor salesmanager of the Alemite division of Stewart-Warner Corporation, has announced.

The four systems are compared and illustrated, and tabular data to permit easy selection of the proper system for any given lubrication



requirement is contained in the catalog.

A highlight of the catalog is a spread showing phantom views of the four systems—Lubrometer, Midget Lubrometer, Dual Progressive and Dual Manifold, in as many typical machine installations. The catalog is copiously illustrated with cross-section views of the valves used in each system, showing progressive stages in the actual operational cycle. Methods of lubricant supply and types of lubrication fittings used in conjunction with all four systems are also detailed.

CHAPMAN JOINS TUTHILL

The appointment of E. W. Chapman as vice president in charge of engineering, effective September 1, 1948, has just been announced by Mr. G. B. Tuthill, president of the Tuthill Pump Company of Chicago.

Mr. Chapman is widely known in industry for his wide experience in the rotary pump field. Before joining Tuthill, he served in a similar capacity for Bowser, Inc., Industrial Pump Division, at Ft. Wayne. Prior to this, he was associated with the Blackmer Pump Company, first as development engineer and later as chief engineer.

A graduate of the School of Mechanical Engineering at Purdue University, Mr. Chapman served as a Lieutenant in the 310th Engineers during the first world war.

LINCOLN ADVANCES LAWTON

In addition to continuing as manager of the Lincoln Engineering Company sales branch in Detroit, Morgan B. Lawton has been appointed to also serve as manager of Lincoln Lubricating Systems, Inc., Cleveland. This announcement was made by E. P. Stuart, general sales manager of Lincoln Engineering Co., St. Louis, manufacturers of lubricating equipment

Ralph Morens, who was made assistant manager for Lincoln Engineering Company branch in Detroit last February will continue in that capacity. Warren Cline, who has been with Lincoln Engineering Company for twelve years, has been made assistant manager of Lincoln Lubricating Systems, Inc., Cleveland.

Mr. Lawton has been with Lincoln Engineering Company since 1937. Pre-war he served in various territories as field representative. During the war as Captain and subsequently Major in Army Ordnance he was made responsible for standardization of lubricating equipment for Army Ground Forces, for which work he was decorated with the Legion of Merit. From 1945 to January, 1947, Lawton served as special assistant to the general sales manager of Lincoln Engineering Company, and early in 1947 he was made manager of the branch in Detroit.

NEW GUN FILLER

A new patented combination grease pail and follower plate, put on the market by the Inland Steel Container Company, has a number of distinct advantages for both distributor and user. It is called the Inland Kleen-Fil grease gun Filler Pail.

Inland's exclusive method of attaching the follower plate to the cover was designed to save time and labor when filling the pails with grease. No separate handling is necessary because cover and plate come off as a unit.

The grease gun is inserted through the large U-Press-It opening in the cover and fits into the opening in the follower plate. A slight pressure releases the plate and with more pressure the grease is quickly and uniformly drawn into the gun barrel. There are no air pockets and the grease is always kept perfectly clean.

A heavy sponge rubber gasket on the follower plate sweeps the inside of the pail clear of grease as the

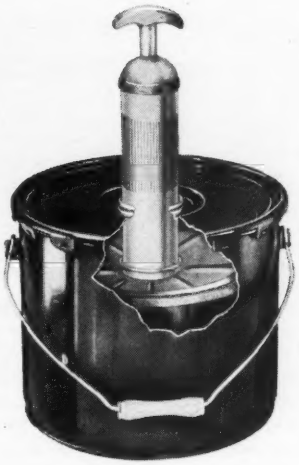


plate is depressed. The sponge rubber gasket adapts itself to dents in the side of the pail

Company name, trade mark and sales message may be lithographed on the pail or the pail may be obtained in standard colors. Literature on the new Kleen-Fil pails is available upon request to the Inland Steel Container Company, 6532 So. Menard Avenue, Chicago 38, Ill.

NICE BALL BEARING EXPANDS

Due to a constantly increasing volume that has been maintained since the close of the war, the Nice Ball Bearing Company has found it necessary to increase its manufacturing facilities by enlarging its plant at 30th and Hunting Park Avenue, Philadelphia 40, Penna.

A completely modern, separate office building is now being constructed, and the vacating of present office quarters will provide additional, much needed factory space.

The Nice Ball Bearing Company, one of the pioneers in the industry, has specialized in the manufacture of ball bearings for almost half a century.

Bryant New Chief

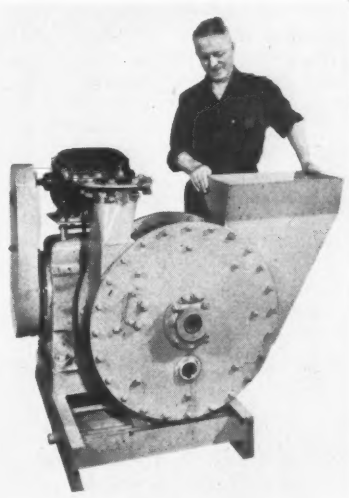
C. E. Hartwig, Director of Research for Swan-Finch Oil Corp., is pleased to announce the promotion of W. C. Bryant to the position of Chief Research Chemist. For the past two years Mr. Bryant has been a group leader in the Research Department. Previously, he had spent eight years in the Production Division as a Control and Chief Chemist.

NEW ROTO-FLO PUMP

Reduction in the cost of handling semi-solids in a wide variety of industries is forecast in the introduction of a revolutionary rotary pump designed and manufactured by the Roto-Flo Pump Corporation, 249 N. Water St., Milwaukee 2, Wisconsin.

The Roto-Flo Pump can handle any material which has a viscosity that enables it to travel through a pipe, and can transmit this material either vertically or horizontally, as required. Where the specific gravity and pipe friction are known the pump can be engineered to meet varying conditions and materials.

According to the company, Roto-Flo Pump enables manufacturers to eliminate open conveyor systems, trucking, hand labor and high costs, in addition to speeding up plant output.



The Roto-Flo Pump operates on a time-tried principle, with the basic element consisting of a hopper and revolving blades. As the rotor revolves, the blades are carried under the hopper where they are consecutively loaded and material is carried around to the discharge opening. At this point the blade is smoothly retracted until it is completely within the rotor as it passes a scraper plate. The material is scraped into the discharge opening and forced through the pipe or conduit. The blade continues around and is gradually extended until it reaches the hopper where it is again loaded. The pump produces a positive, regular and continuous flow of material.

NEW MORSE CATALOG

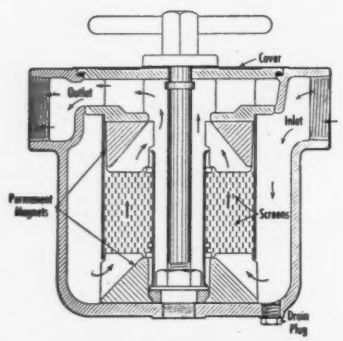
Morse Chain Company, Detroit, has a brand new 16-page, 2-color catalog ready for distribution on request.

The catalog is devoted to the new Morse-Formsprag Full Complement Over-Running Clutch, its construction, development and working principle.

Morse-Formsprag Clutches, available in All-Purpose, Indexing and Plain Bearing Types, have already won a keen reputation for accurate indexing, positive action and instant engagement and disengagement, wherever used.

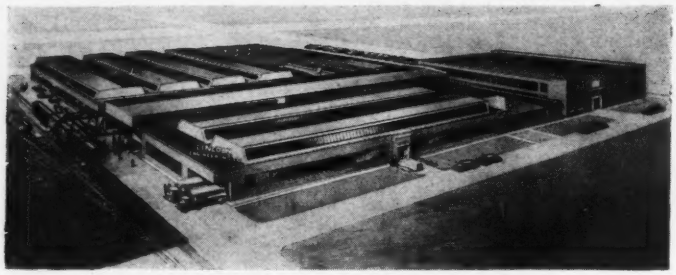
The new catalog gives engineering diagrams of special designs at work with the Morse-Formsprag Clutch integrated within the designs. Successful Morse-Formsprag applications include jet aircraft engines, press roll feeds, generators, blower fans and many other versatile drive mechanisms.

The new Morse-Formsprag Catalog, C11-48, can be obtained by writing Dept. 22, Morse Chain Company, 7601 Central Avenue, Detroit 8, Michigan.



MAGNET FERROFILTER

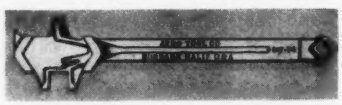
The S. G. Frantz Co., Inc. announces the new and improved Series PQ Permanent Magnet Ferro-Filter, a magnetic separator for the extraction of iron and steel particles from circulating lubricating oils, hydraulic oils, and coolant liquids. The filter is said to catch ferrous particles as fine as one micron, does not remove oil additives or compounding agents, has no moving parts, and no electrical connections are required. For further information, write S. G. Frantz Co., Inc., 161 Grand St., New York 13, N. Y.



NEW LINCOLN ADDITION

Illustrated in the aerial view above, is the plant of the Lincoln Engineering Company, St. Louis, with its new Administration Building recently completed. This modern two-story building, which is the fourth addition in eleven years, adds approximately 34,000 square feet of floor space, and provides for enlarged administrative facilities together with a Display Room for the Company's complete line of lubricating equipment, Service School, Salesmen's Training Facilities, and a completely equipped Demonstration Room with a power-operated automotive lift and a pit installation.

Completion of the new building affords relief to the company's expanded operations and the demand for Lubricating Equipment and allied products.

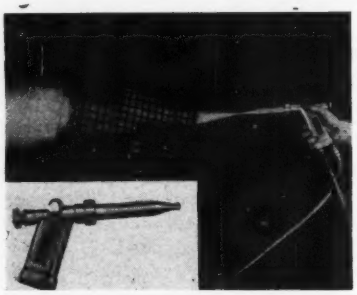


NEW DRUM WRENCH

Aero No. 5001—Universal Type Wrench has sockets and lugs so placed to fit all standard steel drum closures. Also has a steel lip for removing steel caps over drum closures. The wrench will fit male, female and hexagon drive closures, also closures driven by internal lugs; is made of cast steel, cadmium plated to prevent sparking. Weight 2½ lbs. Further information can be obtained by writing Aero Tool Company, 6930 Avalon Boulevard, Los Angeles 3, California.

C. & C. REVISE BOOKLET

A new and revised edition of the booklet, "Physical Properties of Synthetic Organic Chemicals," has just been issued by Carbide and Carbon Chemicals Corporation, a Unit of Union Carbide and Carbon Corporation. This 12-page booklet has been designed as a condensed guide for users of organic chemicals. It contains data on applications and physical properties for more than 185 synthetic organic chemicals. The material is presented in tabular form for ready and easy reference. Copies may be obtained without charge by writing to Carbide and Carbon Chemicals Corporation, 30 East 42nd Street, New York 17, N. Y. Ask for Form 6136.



NEW PRESSURE WASHER

An improved pressure washer, the Hydro-Air, with a broad range of applications to industrial cleaning jobs, has been announced by D & M Products, Inc., 4655 Kingswell Avenue, Los Angeles 27, California.

Using a precisely controlled mixture of water and compressed air, the Hydro-Air produces a blast of "cold steam" that penetrates and cleans without back splash or harm to finish.

The Hydro-Air pressure washer will effect a saving of time and labor in metal processing, maintenance and repair and degreasing or paint stripping departments. Through the use of varying adjustments, the washer can remove heavy dirt and grease or quickly and thoroughly rinse cleaning solvent from sheets and parts.

Virtually any industry in which there exists a problem of cleaning raw materials, equipment or parts will find time-and-labor saving applications for the Hydro-Air pressure washer.

(*Continued on page* 234)

NEWS OF THE SECTIONS

THREE NEW SECTIONS IN NEW ENGLAND

Boston

On August 23rd a meeting was held at the Statler Hotel in Boston where plans were completed for the organization of a Boston Section of the A.S.L.E. The Organizing Committee was elected as follows: A. E. Baker, P. B. Lewis, Dr. E. F. Wilcock, S. T. Douglas, E. M. Higgins.

The permanent officers will be listed on the Section Officers' page in the December issue.

The meeting was well attended and there was a great deal of enthusiasm on the general subject of Lubrication being brought into the forefront through this new Section. National Secretary, W. F. Leonard, was present and turned over the approved set of By-Laws which were adopted. The first technical session will be held the latter part of October. The date will be announced later.

Rhode Island

On Tuesday evening, August 24th, a large group met at the Sheraton-Biltmore Hotel in Providence and adopted the regular Constitution and By-Laws as a Section of the A.S.L.E. The Organizing Committee was elected as follows: Howard G. Jones, Prof. Joel Warren, G. Ritchie, O. S. Edmiston.

The permanent Officers will be listed on the Section Officers' page in the December issue. Earlier in the day, your secretary had the pleasure of motoring from Boston to Providence with Mr. O. S. Edmiston. It was a delightful trip and we arrived just in time for the meeting which was well attended. The first technical session will be held in the latter part of October.

Connecticut

On Thursday evening, August 26th, a meeting was held at the Taft Hotel in New Haven, Conn. The A.S.L.E. Constitution and By-Laws were adopted and permanent Officers elected. (These will be found under the regular Section Officers' listing.) The first technical session will be held in the latter part of October.

The Society extends a hearty welcome to its three newest Sections, all in the New England States, as described above. Your Secretary desires to express his appreciation for the wonderful hospitality extended to him in the three cities. It was very gratifying to note the interest displayed in industrial lubrication, and the personal contacts made were most pleasant and stimulating. We predict a great future for these new Sections.

FORT WAYNE

On Thursday evening, September 9th, there was a meeting held at the Van Orman Hotel in Fort Wayne, Indiana, attended by 26 local men concerned with the Lubrication industry. The group formally organized the Fort Wayne Section of the A.S.L.E. Mr. N. H. Schell of the International Harvester Company was the Chairman of the Organization Committee and gave those present a resume of their past activities in forming the Section. After a lengthy discussion, the permanent group of officers was unanimously elected to carry on the affairs until their last meeting in May, 1949. Meetings were scheduled each month beginning in October, until the starting of the summer season. Arrangements were made for various speakers on several different topics to be heard throughout the year. Altogether the new Section got away to a very enthusiastic start.

The Officers and Directors of the National Society take pleasure in welcoming the newest Section to be formed. Officers elected:

N. H. Schell of International Harvester Co., Chairman.

J. W. Buckner of General Electric Co., Vice-Chairman.

James Michell of Shell Oil Co., Secretary-Treasurer.

Paul Bundy of Salisbury Axle Co., Chairman Program Committee.

There has not been sufficient time to get complete mailing addresses for this issue of "L.E." The December number will carry this information on our regular Section Officers' page.

OBITUARY

It was a great shock to the many friends of John H. Sipchen to hear that he passed away from a heart attack while playing golf, August 21, 1948. Mr. Sipchen was 53 years old and in perfect health up to the day of his death. He was head of J. H. Sipchen & Company, which represents many different mechanical lines. He is survived by his wife, Marie Sipchen, and three daughters, Mrs. Elaine Polkow, Miss Ruth Sipchen and Mrs. Maybelle Vranicar. He was a member of many social orders and particularly active in the A.S.L.E. The Chicago Section will miss his loyal support and fellowship.

CHICAGO

Mr. Carl Schmitz, Program Chairman, announces the following program for the Sectional activities starting in October:

Oct. 21, 1948—Dr. James I. Clower of Delaware University, speaking on the general subject of "Lubrication."

Nov. 18, 1948—Dr. H. V. Miles of the Honan-Crane Corp.

Dec. 16, 1948—Program to be announced.

Jan. 20, 1949—Mr. Edward M. Glass of Wright Aeronautical.

Feb. 17, 1949—Mr. Charles E. Pritchard of Republic Steel Co. who will speak on the subject of "Automatic Lubrication."

Mar. 17, 1949—Mr. Charles L. Pope of Eastman Kodak Company.

Apr. 21, 1949—Mr. Carl Georgi of Quaker State Oil Company.

May 19, 1949—Election of Officers and technical program to be announced.

The meetings will all be opened with a sponsored cocktail hour. Chicago is looking forward to a successful and interesting season.

(*Continued on page* 229)

A.S.L.E. Section Officers

Baltimore:
Chair., V. A. Ryan, Crown Cork & Seal Co., Inc., Eastern Ave. & Kresson St., Baltimore 3, Md.
V. Chair., A. E. Cichelli, Bethlehem Steel Company, *802 E Street, Sparrows Point 19, Md.
Secy.-Treas., P. Raymond Staines, The Davison Chemical Corp., Curtis Bay Plant, Baltimore 3, Md.

Buffalo:
Chair., J. E. Farry, Alemite Co., *348 Florida Ave., Buffalo, N. Y.
Co-Chair. (U.S.A.), C. L. Pope, Eastman Kodak Co., Kodak Park, Rochester 4, N. Y.
Co-Chair. (Canada), G. T. Wright, Dominion Foundries & Steel, Ltd., Depew St., Hamilton, Ontario, Canada.
Secy., N. C. Morrell, Eastman Kodak Co., 333 State St., Rochester 4, N. Y.
Treas., G. Findlay, Republic Steel Corp., 1175 S. Park Ave., Buffalo 20, N. Y.

Chicago:
Chair., N. C. Penfold, Armour Research Foundation, 35 W. 33rd St., Chicago 16, Ill.
V. Chair., C. E. Schmitz, Crane Packing Co., 1800 Cuyler Ave., Chicago 13, Ill.
Secy-Treas., D. S. Gray, Armour Research Foundation, 35 W. 33rd St., Chicago 16, Ill.

Cleveland-Youngstown:
Chair., Edwin Crankshaw, Cleveland Graphite Bronze Co., 17000 St. Clair St., Cleveland 10, Ohio
V. Chair., Charles A. Geisinger, B. F. Goodrich Co., 500 S. Main St., Akron 18, Ohio
Secy., Charles H. Frazier, The Torrington Co., 16004 Detroit Ave., Cleveland 7, Ohio
Treas., J. W. Kasmark, Lincoln Engineering Co., *596 E. 103rd St., Cleveland, Ohio

Connecticut:
Chair., C. R. Gillette, New Departure Division, General Motors Corp., *Vanderbilt Road, Bristol, Conn.
V. Chair., F. E. Stockwell, Esso Standard Oil Co., *40 Elmwood Road, New Haven 15, Conn.
Secy.-Treas., C. A. Pethybridge, New Britain Machine Co., *107 Pendleton Road, New Britain, Conn.

Dayton:
Chair., R. F. McKibben, National Cash Register Co., *241 N. Smithville Rd., Dayton 3, Ohio
Secy.-Treas., R. Lyle Brace, Brace Engineering Co., 440 E. Schantz Ave., Dayton 9, Ohio

Detroit:
Chair., P. W. Uhl, Detroit Diesel Engine Div. G. M., 13400 W. Outer Dr., Detroit 23, Mich.
V. Chair., P. D. Wright, Motor Transport Division, City of Detroit, 2650 E. Jefferson Ave., Detroit 7, Mich.
Secy., J. W. Hopkinson, Penn-Petroleum Corp., 7131 Westfield at Burnette, Detroit 4, Mich.
Treas., B. B. Phelps, Honan-Crane Corp., *2156 Cadillac Blvd., Detroit 4, Mich.

Indianapolis:
Chair., I. S. Bigger, Socony-Vacuum Oil Co., Inc., *3710 Central Ave., Indianapolis, Ind.
V. Chair., D. H. Wilson, Continental Steel Corp., South Plant, Kokomo, Ind.
Secy.-Treas., J. E. Burns, Jr., Crescent Oil Co., 514 W. Wyoming St., Indianapolis 2, Ind.

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Members shall be: (1) persons not less than twenty-four years in age who are engaged in research and instruction at technical schools, universities and various publicly and privately supported institutions in the field of lubrication; or (2) persons not less than twenty-four years in age who have occupied recognized positions as Lubrication Engineers for a period of three or more (not necessarily consecutive) years prior to date of admission, involving the responsibility for or supervision of the development, selection, field use and application of lubricants as differentiated from other activities; or (3) persons not less than twenty-four years in age who are indirectly concerned with the field of lubrication, but possessing other qualifications of experience, knowledge and accomplishment, have manifested a particular interest in the purposes and welfare of the Society, to the extent that their membership would be a valuable contribution to the successful functioning of its activities.

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*Denotes Residence Address Preferred.

NEWS OF THE SECTIONS

(*Continued from page* 227)

DAYTON SECTION ANNOUNCES YEARBOOK

The following editorial submitted by Mr. E. M. Glass of the Program Committee of Dayton covers the subject so ably and thoroughly that we are publishing it in its entirety. We feel this is a worth while effort and think the Dayton Section merits commendation. The project indicates the growth of the Section and cannot help but insure its future success.

"The editors of the *Yearbook* of the Dayton Section of the American Society of Lubrication Engineers were presented with the task of preparing a publication to spread the gospel of "Lubrication Engineering." This job was not considered to be a chore since each member of the editorial staff was sincerely convinced of the need for justifying "Lubrication Engineering" to management and furnishing practical information to the man behind the man behind the grease guns and oil cans.

After due consideration, it was decided that the best approach to this end publication-wise would be to prepare a permanent record of the past year's activities of the Dayton Section, blended with information obtained from the literature and from the experience of the lubrication engineers of the Dayton Section; refined by means of statements of wisdom of National and local Officers; and distributed as the *Yearbook,* with the hope that it will be of value to YOU in your daily work and will furnish information on the value that membership in the Dayton Section offers.

It is intended that the *Yearbook* will be issued annually and that the future editorial staffs may improve from year to year on this initial effort."

Retraction

In the June issue, we reported that Mr. Bryan Malley of Toronto, Ontario, a member of the Industrial Department of the Shell Oil Co., Ltd., gave a talk before the Buffalo Section of A.S.L.E. on May 14th. This was an error on our part. We had received the early announcement of the meeting with the proposed program, but after we had gone to press, the plans were changed. We trust we have caused Mr. Malley no inconvenience.

BUFFALO

The first meeting of the fall season of this Section was held at the Westbrook Hotel, September 15, 1948, with a dinner at 6:30 P.M., the meeting started at 8 o'clock. The subject was, "What to Look for in Fluid Mediums for Hydraulic Systems," by Anthony J. Zino, a member of the Swan-Finch organization. National President George L. Sumner attended and gave a talk on the progress and development of the National Society. The Section elected new Officers for the coming season. (See Section Officers' page.)

OCTOBER COVER, L.E.— SAN FRANCISCO

Spanish settlers founded San Francisco. Originally a colony of Spain, it then became part of the Mexican Republic, finally coming under the jurisdiction of the United States in 1846. The real impetus to its growth occurred in the years immediately following the discovery of gold in 1848. Completion of the Panama Canal in 1914 brought the whole Pacific Coast as close to the Atlantic seaboard, commercially, as Chicago and other Mississippi points. San Francisco serves as the outbound gateway to the Pacific and inbound gateway to the western, midwestern and eastern United States. More than 177 shipping lines regularly pass through the Golden Gate and due to its progressive attitude towards commercial aviation, San Francisco has become a world air terminal and a world trading port where all races and cultures mingle. Conscious of its golden past, San Francisco is showing its traditional vitality in meeting the challenge of today's golden opportunities. The San Francisco Section of A.S.L.E. is imbued with the spirit of the city of which it is a part—a symbol of the future.

CLEVELAND-YOUNGSTOWN

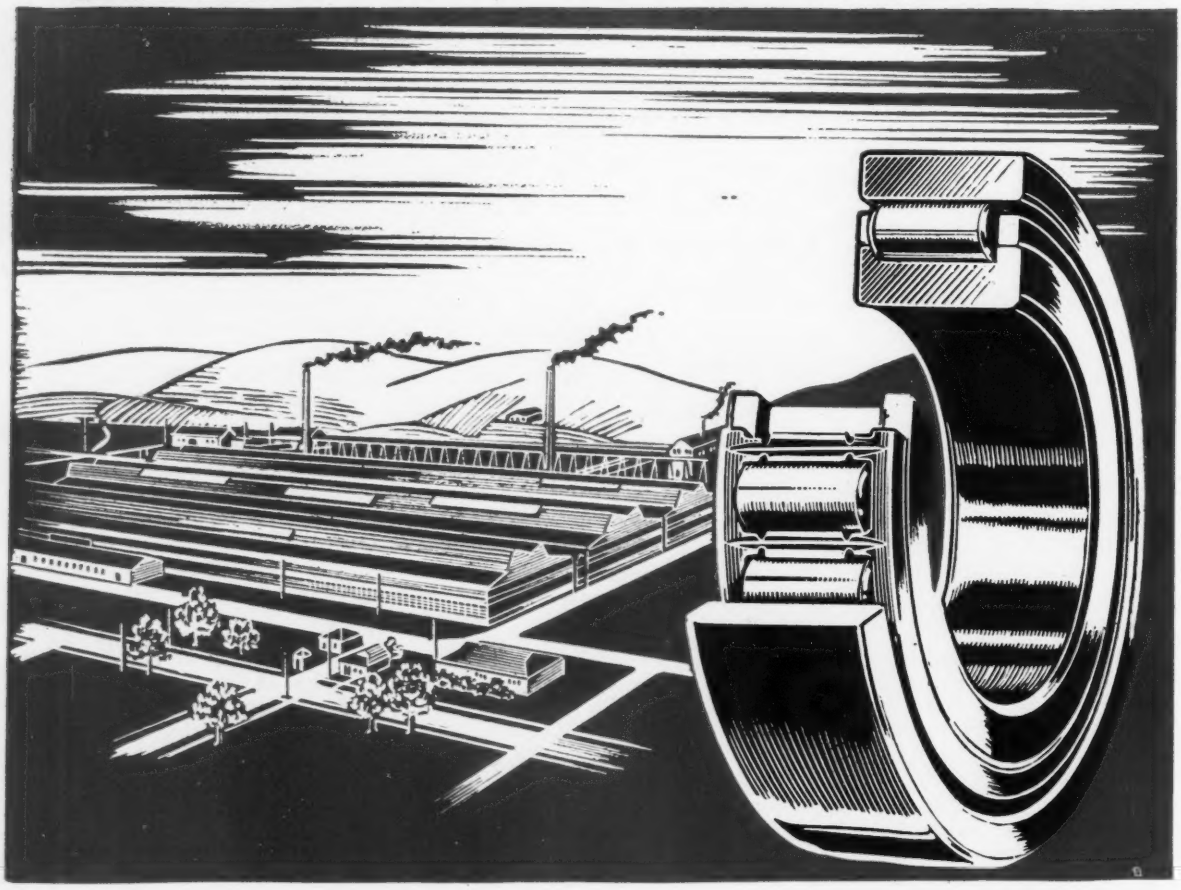
As we go to press, the Cleveland-Youngstown Section are perfecting final arrangements for a golf and clam bake party at Firestone Municipal Golf Course at Akron, Ohio. A great deal of preparation and planning has been done by the Committee and they expect a fine turnout. We shall await a final report of the golf scores.

DIRECTORS MEET

A meeting of the Board of Directors of the Society was held May 25th. A great many matters important to the membership were discussed, among which were an increase from $3.00 to $4.00 in the subscription price for LUBRICATION ENGINEERING and an increase in the annual dues from $10.00 to $12.50. Both increases are in keeping with the general rise in all costs and will go into effect January 1, 1949.

(*Continued on page* 234)

YES! Tycol Acylkup Greases perform better...BETTER...BETTER



Tycol Acylkup Greases perform better because:

. . . *Tycol Acylkup Greases* contain paraffine base cylinder oil, thus assuring greater load carrying capacity and a strong "film of protection."

. . . *Tycol Acylkup Greases* are water-repellent and blended with the finest calcium soap, enough to make every application "stay put" at all times.

. . . *Tycol Acylkup Greases* have a smooth, non-fibrous structure that permits easier application in grease guns and central lubricating systems.

. . . *Tycol Acylkup Greases* safeguard precision anti-friction bearings and heavily loaded gears alike . . . *save* by standardizing on Tycol!

Complete information on Tycol Acylkup Greases is available from your nearest Tide Water Associated Office. Call or write in today.

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INDUSTRIAL HYDRAULICS CONFERENCE

The fourth annual conference on Industrial Hydraulics will be held at the Sheraton Hotel, Chicago, Illinois, on October 20-21, 1948. It is sponsored by the Armour Research Foundation and Graduate School of Illinois Institute of Technology, with the co-operation of various Engineering Societies. An interesting program has been prepared, with a luncheon session at 12:30 P. M. and the annual dinner at 7:00 P. M., both on Wednesday, October 20th, with many nationally known speakers on the program. Mr. Carl E. Schmitz, Vice President of the Crane Packing Company of Chicago and Vice Chairman of the Chicago Section of A.S.L.E., will represent our Society with a talk on "Hydraulic Packings and Seals." Mr. W. H. Oldacre of D. A. Stuart Oil Company, Chicago, Illinois, will speak on the A.S.M.E.'s relationship to the Conference.

SOCIETY MEETINGS

November 3-4 — American Society of Mechanical Engineers, Fuels Division, Greenbrier Hotel, White Sulphur Springs, W. Va.

November 4-5 — Society of Automotive Engineers, Fuels and Lubricants Division, Mayo Hotel, Tulsa, Okla.

November 7-10 — American Institute of Chemical Engineers, Pennsylvania Hotel, New York, N. Y.

November 8—Oil Industry Information Committee, Stevens Hotel, Chicago, Ill.

November 8-9—American Petroleum Institute (Lubrication Committee) Stevens Hotel, Chicago, Ill.

November 8-9—National Council of Independent Petroleum Associations (National Oil Jobbers Council), Sheraton Hotel, Chicago, Ill.

November 8-11—AMERICAN PETROLEUM INSTITUTE (28th annual meeting), Stevens Hotel, Chicago, Ill.

November 10 — American Society for Testing Materials (Philadelphia District) Franklin Institute, Philadelphia, Pa.

MAAG AND KIPP SPEAK

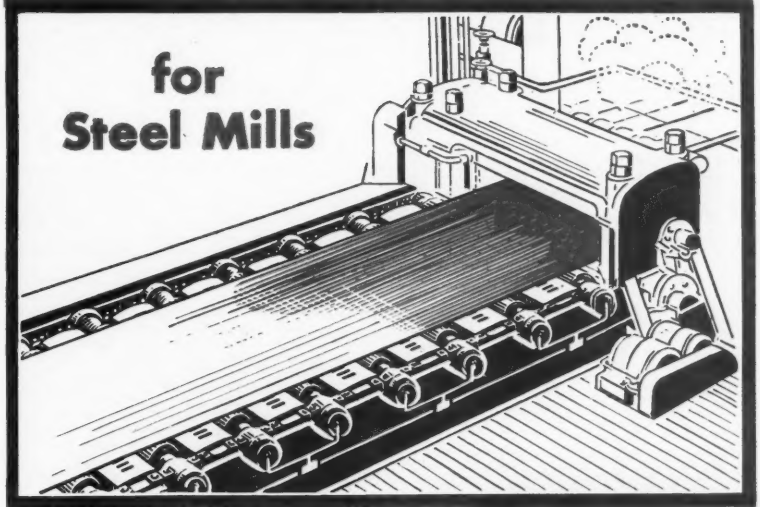
The 16th annual meeting of the National Lubricating Grease Institute will be held at the Edgewater Beach Hotel, Chicago, October 11, 12, and 13, 1948. Members of the A.S.L.E. will be interested to know that Mr. O. L. Maag of Timken Roller Bearing Co. will speak on "Lubricants for Various Roller Bearing Applications." Dr. E. M. Kipp of Aluminum Company of America talks on "All Purpose Greases." Both Mr. Maag and Dr. Kipp are past Presidents of the A.S.L.E. The usual banquet will be held in the ballroom at 7:00 P. M., Tuesday evening, October 12th.

A.S.L.E. MEMBERSHIP DRIVE

With the opening of the October Section meetings, Co-Chairmen Frank Ross of E. F. Houghton & Co. and William P. Youngclaus of Stewart-Warner Corp., Alemite Division, announce the completion of their program for a membership drive in industry with the preparation of new material to demonstrate to industrial management the value of membership in the Society for all of their employees who are identified with any phase of Lubrication. It is felt that there is a growing necessity for information on this very vital subject, and with the extension of membership in the Society, much benefit can be obtained by industrial concerns all over the country. The Society now has 19 Sections holding monthly educational meetings, covering hydraulics, cutting oils, spindle oils, gear case oils and other relative topics. Interesting practical papers will be delivered by outstanding men allied with industrial Lubrication; informative discussions of everyday and unusual Lubrication problems; and discussions where oil men, consumers and machine tool men get together and arrive at practical solutions of everyday difficulties.

Herein lies a story
... of operating economy

for Steel Mills



Through continuing, painstaking study of the severe requirements of steel mill lubricants, Swan-Finch has developed a line of greases that has become a standard of comparison in the industry.

Among these lubricants which have proved particularly effective in increasing lubricating efficiency and reducing lubrication costs are

- *Safco* C 1247 roll neck grease
- *Safco* 1235 and 424 furnace table bearing greases
- *Safco* cooling bed grease
- *Cascade* 90 Series EP waterproof gear and bearing greases

Reduced maintenance costs—less time out for repairs—increased production is the theme of the story all the way through—from large mills and small—for centralized lubrication systems or for unit applications—for extreme conditions as well as the more normal. Volumes could be written about the economies effected by mill operators on thousands of applications.

If you are not now benefiting from the savings that these greases will show, call in a Swan-Finch lubricating engineer; he will recommend the *right* lubricant for your particular job.

SWAN-FINCH OIL CORPORATION
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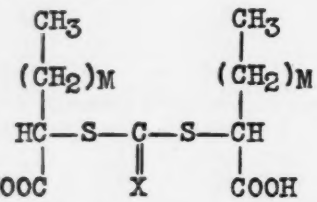
OILS AND LUBRICANTS PATENT ABSTRACTS

Pigmented Emulsion Type Coating Composition—Patent #2,440,953—John W. Iliff and Martha Torrey, assignors to E. I. duPont deNemours & Co.

A coating composition having a luster when dry, comprising an oil-in-water emulsion in which the inside phase contains a titanium dioxide pigment in addition to a member of the group which consists of drying oil modified alkyd resins, semi-drying oil modified alkyd resins and oleo-resinous varnishes, the pigment particles being coated with an amphoteric metal compound selected from the group which consists of aluminum hydroxide, silicon hydroxide, titanium hydroxide, tin hydroxide, titanium silicate, tin silicate, zirconium silicate, lead silicate, and cerium silicate.

Oil Compound—Patent #2,440,991—Stephan J. Wayo, assignor to Sinclair Refining Co.

An improved mineral oil composition, especially adapted to use as a turbine oil, which comprises a petroleum lubricating oil fraction with which there has been compounded a minor proportion, effective to retard rusting, of an alpha, alpha'-thiocarbono-dialiphatic acid represented by the structural formula:



in which X is from the group sulfur and oxygen and m is one of the integers 13 and 15.

Lubricating Oil Compositions Containing Polymerized Allyl Esters of Carboxylic Acids—Patent #2,441,023—Robert G. Larsen and Kenneth E. Marple, assignors to Shell Development Co.

A lubricating composition comprising an oily lubricant and a sufficient amount to increase appreciably the viscosity index of said oily lubricant of a polymer of an ester of an allyl alcohol containing 3 to 18 carbon atoms with a saturated monocarboxylic acid containing 8 to 13 carbon atoms, said ester having a double bond of aliphatic character between two carbon atoms one of which is attached directly to a saturated carbon atom which in turn is attached directly to the ogygen atom of the carboxyl group of the ester, and said polymer, having a degree of polymerization of 4.3 to 12.1, being obtained by heating and polymerizing said ester at 50°C. to 300°C. in intimate mixture with a polymerization catalyst of the group consisting of peroxides and molecular oxygen.

Modified Fuels and Lubricants—Patent #2,441,172—Sol Shappirio.

A liquid petroleum distillate containing a metallized amino azo dye.

Treatment of Tall Oil—Patent #2,441,197—Nicholas L. Kalman, assignor to Ridbo Laboratories, Inc.

A method for treating tall oil comprising heating the tall oil in the presence of from 0.5% to 10% of an agent selected from the class consisting of phosphorous acids, oxides, sulfides, chlorides, and oxychlorides, at a temperature between about 250°C. and about 350°C., and distilling the volatile constituents of tall oil to recover a product essentially consisting of a mixture of fatty acids and rosin hydrocarbons.

Tall Oil Treatment—Patent #2,441,198—Vigen K. Babayan, assignor to Ridbo Laboratories, Inc.

A process for separating constituents of tall oil, which process comprises preliminarily heating the tall oil with from .5% to 5% of a treating agent selected from the class consisting of phosphorus pentoxide and ortho-phosphoric acid at a temperature between about 250°C. and 350°C., distilling off the distillable constituents and during distillation maintaining a zone of distillate vapor temperature of from about 250°C. to about 310°C., the preliminary heating and distillation being carried on for a time and under conditions effecting substantially complete decarboxylation of the rosin present in the tall oil taken for treatment to thereby yield a distillate essentially consisting of fatty acids and rosin hydrocarbons, and separating the fatty and rosin constituents of said distillate.

Lubricating Oils—Patent #2,441,496—Bert H. Lincoln Gordon, D. Byrkit, and Waldo L. Steiner, assignors to Continental Oil Co.

A lubricant comprising in combination a major proportion of an oil of lubricating viscosity and a minor proportion, sufficient to improve the properties of the oil as regards corrosion and oxidation of sulfurized monomeric olefin, said olefin being obtained from a narrow-cut petroleum fraction and a minor proportion of an organic phosphorus compound.

Printed copies of patents are available from the Patent Office at twenty-five cents each. Address the Commissioner of Patents, Washington, D. C., for copies and for general information concerning patents.

From Official Gazette—Vol. 610, Nos. 1, 2, 3, 4; Vol. 611, Nos. 1, 2, 3, 4, 5.

Prepared by ANN BURCHICK

Method of Preparing Composition of Matter Suitable for Use as a Lubricant and as an Addition Agent to Lubricants—Patent #2,441,587—John M. Musselman, assignor to The Standard Oil Co.

A process of preparing lubricants and additives for mineral oils to improve their lubricating properties, which process comprises reacting a part of a total amount of a phosphorus sulfide at a temperature of at least about 270°F. with an organic oxygen-containing compound having a boiling point above said temperature and reacting with the phosphorus sulfide to form an oil-soluble reaction product, adding an amount of an alkaline reacting compound to neutralize at least part of a phosphorus and oxygen-containing by-product formed in said reaction, reacting the remainder of the amount of the phosphorus sulfide, the total amount being at least about the amount required to complete the reaction that occurs at said temperature.

Lubricant—Patent #2,441,720—Theodore G. Roehner and George W. Murray, assignors to Socony-Vacuum Co., Inc.

A soda soap lubricating grease characterized by resistance to deformation and "bleeding," comprising a sodium soap content of from about 36 to about 50 per cent and from about 0.5 to about 10 per cent of a water-dispersible cellulose ether.

Treating Edible Oils—Patent #2,441,923—Francis Michael Sullivan.

In the process of treating an edible food glyceride oil containing naturally-occurring, undesirable solutes, removing oxygen from the oil, heating said oil in the absence of oxygen at a temperature of at least 200°C. but below that at which the oil is undesirably affected, to produce pyrolysis of undesirable solutes during a re-solution heating period of not more than 180 minutes under conditions of temperature, time of treatment, and agitation insufficient to dissolve substantially any sludge formed, and separating pyrolyzed bodies and any formed sludge to yield a product capable of being deodorized by steam distillation under vacuum to produce an edible food oil.

Lubricant—Patent #2,442,134—Eugene Lieber and Aloysius F. Cashman, assignors to Standard Oil Development Co.

An extreme pressure agent comprising a halogenated petroleum hydrocarbon containing active halogen and sulfur, normally tending during storage to undergo degradation leading to the formation of ingredients which are insoluble in paraffinic mineral oils, also containing a small amount of a stabilizer consisting of a low molecular weight aromatic compound containing a single monocyclic aromatic hydrocarbon group of the formula C_6H_4, the residue of the molecule being composed of atoms selected only from carbon, hydrogen, and oxygen.

Rust Preventive Hydrocarbon Compositions — Patent #2,442,672—George Hugo von Fuchs and Norman B. Wilson, assignors to Shell Development Co.

Rust preventive lubricating oil comprising predominantly a mineral lubricating oil containing dissolved .001% to .1% of a hydrogenated and hydrolyzed product of the reaction of an olefin with maleic acid anhydride and .001% to 1% of an alkyl phenol oxidation inhibitor, said product having at least 20 carbon atoms.

Treatment of Hydrocarbon Oils—Patent #2,442,820—Darwin M. McCormick, assignor to The Atlantic Refining Co.

The method of avoiding emulsification difficulties and promoting the separation of the raffinate phase from the extract phase in the selective solvent extraction of viscous hydrocarbon oil employing nitrobenzene as the extraction solvent, which comprises adding to the extraction system a small amount of an oil-soluble alkaline earth metal sulfonate sufficient to promote phase separation.

Lubricating Greases—Patent #2,442,828—Herschel G. Smith, Mark L. Hill, and Carl Malcolm Peck, assignors to Gulf Oil Corp.

A block grease of spongy texture which is not rapidly consumed at high bearing temperatures which comprises a major amount of a soda lime base block grease, and minor amounts, sufficient to decrease the rate of consumption of said block grease at high bearing temperatures, of the alkali saponification products of a wax selected from the group consisting of carnauba wax and ouricury wax, and of excess alkali in the form of a sodium carbonate, the amount of said wax in the form of its alkali saponification products being from 0.2 to 20 per cent by weight, and the amount of said excess alkali being from about 0.2 to about 0.4 per cent by weight.

Process for Fat Splitting—Patent #2,442,925—Wm. K. Griesinger, assignor to The Atlantic Refining Co.

A method for hydrolyzing fats and fatty oils, which comprises heating said fatty material in admixture with water and a hydrolyzing agent comprising sulfonic acids of a polyalkylated benzene fraction boiling within the range of 400°F. to 550°F.

Stabilized Grease Compositions—Patent #2,443,026—James G. Detwiler, assignor to The Texas Company.

A grease composition stabilized against texture change, comprising a homogeneous mixture of a mineral oil, sufficient metallic soap to thicken the mineral oil to a gel and 0.05-5.0% by weight of tetra methyl diamino diphenyl methane.

Synthetic Drying Oil—Patent #2,443,079—Ferdinand P. Otto, assignor to Socony-Vacuum Oil Co., Inc.

A synthetic drying oil prepared by subjecting aromatic hydrocarbon material consisting largely of dimethyl naphthalenes and trimethyl naphthalenes, to exhaustive catalytic hydrogenation to yield a product consisting largely of alkyl decalins; chlorinating the product of the exhaustive catalytic hydrogenation at temperatures varying between about 20°C. and about 80°C. for a period of time sufficient to yield a chlorinated product containing between about 25 per cent by weight and 35 per cent by weight of chlorine; and dehydrochlorinating said chlorinated product in the presence of calcium oxide for a period of time sufficient to reduce the chlorine content of said chlorinated product to less than about 4 per cent by weight.

Synthetic Lubricant—Patent #2,443,082—Orland M. Reiff, Howard D. Hartough, and Harry J. Andress, Jr., assignors to Socony-Vacuum Oil Co., Inc.

A lubricant of low pour point comprising a synthetic lubricant having incorporated therewith a small amount, sufficient to characterize the said lubricant with a pour point at least as low as 0°F., of an ester of an alkyl-substituted phenol, said synthetic lubricant being prepared from a crystalline paraffin wax having a melting point not greater than about 140°F. and toluene by: partially halogenating the paraffin wax to form a mixture of halogenated wax and substantially unhalogenated wax containing an amount of halogen corresponding to from about 18 to 25 per cent chlorine; mixing the halogenated wax and unhalogenated wax with toluene in the proportion of at least one mole of toluene to each atom of halogen in the halogenated wax mixture; adding thereto a catalyst capable of effecting a Friedel-Crafts type condensation; heating the mixture thus obtained at a Friedel-Crafts condensation temperature until substantially all of the halogenated wax has reacted with said toluene; and separating the Friedel-Crafts catalyst, unreacted toluene and unhalogenated wax from the reaction mixture so obtained, to obtain said synthetic lubricant.

Synthetic Lubricant—Patent #2,443,083—Orland M. Reiff, Howard D. Hartough, and Harry J. Andress, Jr., assignors to Socony-Vacuum Oil Co., Inc.

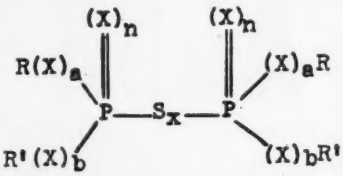
A lubricant of low pour point comprising a synthetic lubricant having incorporated therewith a small amount, sufficient to characterize the said lubricant with a pour point at least as low as 0°F., of an ester of an alkyl-substituted phenol, said synthetic lubricant being prepared from a crystalline paraffin wax having a melting point not greater than about 140°F. and a xylene by: partially halogenating the paraffin wax to form a mixture of halogenated wax and substantially unhalogenated wax containing an amount of halogen corresponding to from about 21 per cent to about 24 per cent chlorine; mixing the halogenated wax and unhalogenated wax with said xylene in the proportion of at least one mole of xylene to each atom of halogen in the halogenated wax mixture; adding thereto a catalyst capable of effecting a Friedel-Crafts type condensation; heating the mixture thus obtained at a Friedel-Crafts condensation temperature until substantially all of the halogenated wax has reacted with said xylene; and separating the Friedel-Crafts catalyst, unreacted xylene and unhalogenated wax from the reaction mixture so obtained, to obtain said synthetic lubricant.

Breaking Water-In-Oil Emulsions—Patent #2,443,273—Richard A. Salathiel, assignor to Standard Oil Development Co.

A method for resolving a petroleum emulsion of the water-in-oil type into its components which comprises adding to it the salt of the reaction between a petroleum sulfonate having a first heptane salt number greater than 2 and a second heptane salt number less than 23, and an organic amine containing only carbon, hydrogen, and one atom of nitrogen per molecule and having a molecular weight between 55 and 200 and a dissociation constant between 1×10^3 and 5×10^6.

Compounded Lubricating Oil—Patent #2,443,264—Louis A. Mikeska, assignor to Standard Oil Development Company.

A mineral lubricating oil containing a small quantity sufficient to stabilize said oil in the presence of oxygen but not greater than about 1% of a compound of the formula



where R and R^1 are organic groups selected from the class consisting of aliphatic, aromatic and aliphatic-aromatic groups, X is a member of the group consisting of oxygen and sulfur and is joined to a carbon atom or group R or R^1, a, b and n are each 0 or 1, and x is an integer from 2 to 4.

Mineral Oil Composition—Patent #2,443,578—Everett W. Fuller and Ralph V. White, and Bertrand W. Story, assignors to Socony-Vacuum Oil Co., Inc.

A mineral composition comprising a mineral oil fraction normally incapable of preventing rusting of ferrous metal surfaces in the presence of water, and in admixture therewith a minor proportion, sufficient to inhibit said rusting, of a mixture of neutral and partial esters of a hydroxy-substituted aliphatic dicarboxylic acid and a long-chain aliphatic alcohol having at least 18 carbon atoms, said mixture containing at least 2 per cent of a partial ester.

Mineral Oil Composition—Patent #2,443,579—Everett W. Fuller and Ralph V. White, and Bertrand W. Story, assignors to Socony-Vacuum Oil Co., Inc.

A mineral oil composition comprising a mineral oil fraction normally incapable of preventing rusting of ferrous metal surfaces in the presence of water, and in admixture therewith a minor proportion, sufficient to inhibit said rusting, of a mixture of neutral and partial esters of malic acid and oleyl alcohol containing at least about 8 per cent of partial ester.

Cylinder Oils—Patent #2,443,585—Leon Salz and Samuel P. Marley, assignors to Socony-Vacuum Oil Co., Inc.

A steam cylinder lubricant consisting essentially of a mineral oil fraction having a Saybolt viscosity from about 100 seconds to about 300 seconds, at 210°F., and a flash point of at least about 425°F., and about 0.2% of the esterification reaction product of oleyl alcohol and malic acid, said reaction product containing about 67% of an acid ester of said alcohol and said acid.

Cutting Oil Base—Patent #2,443,833—Latimer D. Myers and Victor J. Muckerheide, assignors to Emery Industries, Inc.

A cutting oil base consisting essentially of alkali metal rosin soap, glyceryl mono oleate and an appreciable amount of oil soluble mineral oil sulphonates, substantially one to two parts by weight of rosin soap being present to each one part of glyceryl mono oleate, the amount of mineral oil sulphonates not exceeding substantially 40% by weight of the whole composition.

Light Stability Petroleum Waxes—Patent #2,444,269—Joseph Phillips, assignor to L. Sonneborn Sons, Inc.

A petroleum wax product substantially resistant to deterioration by exposure to light, which comprises a substantially color refined normally substantially light sensitive petroleum wax and extract derived from the extraction of a petroleum oil distillate with a selective aromatics extractant, said extract being present in said product in amount sufficient to impart thereto substantially permanent light stability.

Lubricant for Drills and Cutting Tools—Patent #2,444,357—Jack H. Maguire, assignor to Lockheed Aircraft Corp.

A cutting lubricant having improved adherence and work penetrating characteristics and a high melting point, consisting essentially of approximately three parts by weight of a mixture of approximately 75% grease, said grease combining approximately 95% mineral oil having a Saybolt viscosity of between 135 and 165 at 212°F. and approximately 5% soap, and approximately 25% turpentine; approximately two parts by weight of paraffin; and approximately 0.44% by weight of aluminum stearate.

From Official Gazette—Vol. 612, Nos. 1, 2, 3, 4; Vol. 613, Nos. 1, 2, 3, 4. 5.

Manufacture of Lithium Base Greases—Patent #2,444,720—James Alfred Bell, assignor to Shell Development Co.

In a process of manufacturing a lubricant containing a lithium soap, the improvement consisting essentially of intimately contacting a quantity of a free soap-forming acid containing at least 16 carbon atoms in the molecule in solution in a lubricating oil with an approximately equivalent quantity of a saponifying agent of the group consisting of lithium oxide, anhydrous lithium hydroxide, lithium hydroxide and its hydrates at a temperature of between about 35° and 45°C. for a time sufficient to react at least 90% by weight of one of said lithium compounds and said acid to form a soap.

Lubricant—Patent #2,444,947—John M. Musselman and Herman P. Lankelma, assignors to The Standard Oil Company.

As a lubricant and as an addition agent for lubricating oils and greases to inhibit their deterioration and improve their E.P. properties, a heavy metal compound of the reaction product of a halogenated oxygen-containing organic compound reacted with an amount of a phosphorus sulfide at least about equivalent to the theoretical amount required to replace the oxygen in the halogenated oxygen containing organic compound with sulfur from the sulfide, reacted at a temperature above 270°F. to form a reaction product which is separable from a phosphorus and oxygen containing by-product residue.

Lubricant—Patent #2,444,948—John M. Musselman and Herman P. Lankelma, assignors to the Standard Oil Company.

As a lubricant and as an addition agent for lubricating oils and greases to inhibit their deterioration and improve their E.P. properties, the reaction product of a halogenated oxygen containing organic compound reacted with an amount of a phosphorus sulfide at least about equivalent to the theoretical amount required to replace the oxygen in the halogenated oxygen containing organic compound with sulfur from the sulfide, reacted at a temperature above 270°F. to form a reaction product which is separable from a phosphrus and oxygen containing by-product residue.

Grease Compositions—Patent #2,444,970—John C. Zimmer and Gordon W. Duncan, assignors to Standard Oil Development Co.

A grease composition comprising a mineral lubricating oil and sufficient of the complex reaction product of an oil soluble metal sulfonate having a molecular weight of approximately 300 to 600 and a salt of an acid selected from the group consisting of low molecular weight aliphatic carboxylic acids, in which at least one cation in the above salts is polyvalent, to thicken the mineral oil to a grease consistency, said complex reaction product being produced by dissolving said sulfonate in said mineral oil and reacting said sulfonate with said salt in the presence of heat.

Distillation of Sulfuric Acid Treated Hydrocarbon Oils—Patent #2,445,655—Harry L. Allen and Herbert G. Kleinguenther, assignors to Allied Chemical & Dye Corp.

In the refining of an aromatic hydrocarbon oil by treatment with sulfuric acid and subsequent distillation, the improvement which comprises eliminating excess acid from the acid treated oil and thereafter distilling the oil in the presence of a compound selected from the group consisting of urea and thiourea.

Production of Greases—Patent #2,445,935—Arnold A. Bondi, assignor, by Mesne assignments, to Shell Development Co.

The method of manufacturing a soda base grease comprising forming a mixture of a lubricating base, a material furnishing a non-hydroxy saponifiable fatty material, metallic sodium, acting as a saponifying agent, and an addition agent selected from the group consisting of the higher hydroxy fatty acids and esters thereof; and heating said mixture until saponification, and the grease making reaction are substantially completed.

Waterproofing of Lubricating Greases—Patent #2,445,936—Richard August Butcosk, assignor, by mesne assignments, to Shell Development Co.

A lubricating grease consisting essentially of a major amount of an oil base having present a minor amount, sufficient to form a grease structure, of a metal soap of a fatty acid, at least 70% of said metal soap being an alkali metal soap of a fatty acid, said alkali metal having an atomic weight varying from about 6.94 to 23.0, from about 1% to about 3% of a hydrocarbon sulfonate, said sulfonate being present in an amount at least sufficient to inhibit rusting of a rustable base in contact therewith, which amount of the sulfonate decreases the water-proofing characteristics of the grease, and a metal soap of a 12-hydroxy-stearic acid, the metal of said latter soap appearing in group 2 of the periodic classification of the elements and having an atomic weight between 24, 32, and 112.4, said metal soap of 12-hydroxy-stearic acid being present in an amount of between about 1% and about 3% to counteract the action of the rust proofing agent in decreasing the waterproofing characteristics of the grease.

Silicone Grease and Method of Preparation—Patent #2,446,177—George M. Hain and William A. Zisman.

A lubricant consisting essentially of an organi-silicon polymer as a base fluid blended with a minor amount of lithium stearate to produce a stable grease.

Process for Regenerating Spent Internal-Combustion Engine Lubricating Oils—Patent #2,446,489—Albert Schaafsma, assignor to Shell Development Co.

The process for regenerating spent internal combustion engine lubricating oil comprising the step of percolating said oil through a bed consisting of activated bauxite of at least one meter thickness at a temperature of about 260°C.

Thickened Lubricant—Patent #2,446,927—Harris D. Hineline, assignor to Standard Oil Development Co.

A liquid lubricant comprising in combination a hydrocarbon oil, a polymer in solution therein comprising a major proportion of isobutylene interpolymerized with a minor proportion of a butadiene having from 4 to 15 carbon atoms per molecule, and a curing agent comprising sulfur chloride in chemical combination with the dissolved polymer.

High Capillarity Lubricating Oil—Patent #2,446,944—John D. Morgan, assignor to Cities Service Oil Co.

A lubricating oil composition comprising from about 40 to 60% of a light bodied mineral lubricating oil, from about 15 to 30% of a petroleum solvent selected from the group consisting of kerosene, No. 2 furnace oil and Stoddard solvent, from about 10 to 15% of secondary butyl alcohol, from about 5 to 15% of commercial xylol, and from about 2 to about 3% of tri-n-butyl phosphate.

Emulsifiable Oils—Patent #2,447,475—Russell A. Kaberg and John Sterling Harris, assignors to Monsanto Chemical Co.

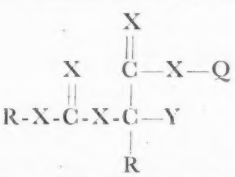
A self-dispersing concentrate for forming stable oil-in-water emulsions comprising an aromatic oil; a biological toxicant; from 3 to 10% by weight of an oil-soluble organic surface-active agent which is a neutral salt and which is selected from the group consisting of sulfonates and sulfates and having a Draves wetting time of less than 10.5 seconds in an aqueous solution consisting of 0.5% by weight of said surface-active agent; and from 3 to 10% by weight of the condesation product of 1 mole of a C_4-C_{18}-alkyl-substituted hydroxy compound of the benzene series and from 8 to 25 moles of ethylene oxide.

Lubricant—Patent #2,447,607—John C. Zimmer and Gordon W. Duncan, assignors to Standard Oil Development Co.

An improved lubricating oil composition consisting essentially of a mineral lubricating oil containing from 0.5 to 5.0% by weight based on the total composition of an alkaline earth metallo-organic detergent composition having a tendency to form emulsions and drop out of oil solution in the presence of water, and 0.05 to 4% of an oil soluble hydrophilic agent selected from the group which consists of phenoxy ethanol and phenoxy isopropanol for stabilizing said detergent in solution of said oil.

Lubricating Compositions — Patent #2,448,037 — Bert H. Lincoln and Gordon D. Byrkit, assignors, by mesne assignments, to The Lubri-Zol Development Corp.

A lubricant comprising in combination a major amount of oil of lubricating viscosity and from 0.001% to 10% of an oil-soluble neutralized organic carboxylic acid bearing a thiocarbonate radicle having the formula:



where C represents carbon; X is an element selected from the class consisting of oxygen and sulphur, at least one X is sulphur; Y is a halogen; R is an organic radicle; and Q is one hydrogen equivalent of a sole-forming radicle.

Penetrating Oil Compositions—Patent #2,448,093—Lewis D. Gittings, assignor to Monsanto Chemical Co.

A penetrating oil comprising in combination a hydrocarbon oil and from 5% to about 60% by volume of dicyclohexyl.

Method of Preparing Oil-Soluble Sulfonates—Patent #2,448,184—Norman E. Lemmon, assignor to Standard Oil Co.

The method of preparing a preferentially oil-soluble alkylated aromatic sulfonate comprising sulfonating an alkylated aromatic hydrocarbon having at least 18 carbon atoms in the alkyl group with sulfur trioxide, blowing the sulfonated alkylated aromatic hydrocarbon with a gas to remove SO_2 and SO_3, contacting the blown alkylated aromatic sulfonic acid with a small amount of an adsorption clay, whereby an alkylated aromatic sulfonic acid substantially free of sulfuric acid is obtained, and neutralizing said clay-contacted alkylated aromatic sulfonic acid whereby a preferentially oil-soluble alkylated aromatic sulfonate having a relatively low inorganic sulfate content is obtained.

Process for Producing Nonbreak Oil—Patent #2,448,434—Jakob L. Jakobson, assignor to General Mills, Inc.

Process of producing a Gardner non-break oil which comprises treating a vegetable oil containing break constituents with a small proportion of a halogenated low aliphatic acid in the presence of water to produce two phases, an oil phase substantially free from break constituents, and an aqueous phase containing the halogenated acid and the break constituents, and separating the two phases.

NEWS OF THE SECTIONS

(*Continued from page* 229)

DETROIT

Seventy-five members and guests attended a very successful Stag Day Golf Party on August 28th at the Lakewood Country Club in Canada. Following the golf tournament, soft ball games and horse shoe pitching contests; an excellent steak dinner was served. Plans for the fall technical sessions were completed, as follows:

Sept. 27th—Rackham Memorial Institute—7:00 P. M. Subject: "Automotive Lubrication," the speaker to be announced.

Oct. 25th — Subject: "Problems Encountered in the Setting Up and Operating of an Engine Laboratory for the Testing of Lubricating Oils" —Speaker: Mr. C. E. Wolmer from Stamford Laboratories of the American Cyanamid Company.

Nov. 22nd—Subject: "Lubricants and Lubrication." Speaker: Mr. Melville Ehrlich, Chief Chemist of American Lubricants, Inc.

The Detroit Section is getting away to a fine start for their fall and winter season. Further programs will be announced later.

PHILADELPHIA

The Philadelphia Section has completed its program for the fall and winter season and has asked us to publish its prospective meetings as follows:

September 30, 1948 — Discussion Symposium Cutting Fluids.

November 18, 1948—Centralized Lubricating Systems.

January 20, 1949 — Promotion - Membership Night. Philadelphia is endeavoring to increase its membership at least 50 per cent together with a general increase in industrial memberships in the National Society. President Sumner will be one of the speakers at this meeting along with executives of several prominent industrial firms.

The two remaining meetings will be on March 17th and May 12th, 1949. Topics as yet have not been definitely set, but will include Lubrication of Textile Machinery and Diesel and Bus Lubrication. All meetings will be held at the Broadwood Hotel, Broad and Wood Sts., Philadelphia, Penna., with dinner at 6:30 P.M., meeting opening at 7:45 P.M. All members and men interested in Lubrication are cordially invited to attend.

BOOK REVIEW

Distillation and Rectification

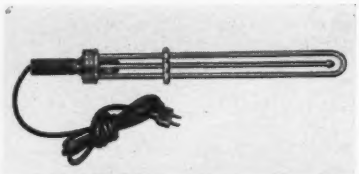
By Dr. Emil Kirschbaum, translated into English by M. Wolfinghoff. Chemical Publishing Company, Inc., Brooklyn, New York, 1948. 426 pages, 5 pocket charts. Price $10.00.

This book, which is outstanding in its field, is the first translation into English of this celebrated German reference book. It presents the results of research together with theory and engineering data in the field of distillation and rectification.

Structural details of apparatus and other factors important to the engineer have been considered. Principles and design features are stressed and both numerical and descriptive examples are numerous throughout the text. Much use has been made of graphical methods in analysis and a large number of tables and graphs are included in the book.

NEWS OF INDUSTRY

(*Continued from page* 226)



NEW IMMERSION HEATER

An entirely Automatic Immersion Heater with adjustable thermostat control has recently been introduced. This unit takes full advantage of all the heat saving features and economy of operation by heating liquids within tanks, kettles, tumblers, etc., where liquids absorb all the heat generated.

An integral part of this instrument is an adjustable thermostat control that maintains any desired temperature at all times to within 1°F tolerance. A safety cut-out prevents element from overheating or burning out when out of solution. Special insulation prevents electric shock.

Five immersion lengths, 5″, 8″, 10″, 15″ and 20″ are available in acid resisting stainless steel. The units are rated at 1000 watts and plug into any standard 110 Volt A.C. outlet.

The heaters are being marketed under the name of "Chill-Chaser" made by The Stillman Company, New York 56, N. Y.

(*Continued on page* 239)

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MECHANISM OF FRICTION

(*Continued from page* 216)

pressure during sliding contact between opposed rounded eminences without being displaced, and (b) to "contaminate" freshly exposed regions, thus preventing the formation of a strong bond when two such regions meet, and so limiting the friction due to surface rupture.

5. Important properties in which lubricants differ are the following:

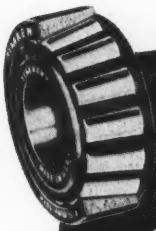
a. Ability to separate opposing rounded eminences as they slide over each other. This depends on the strength of binding of a lubricant molecule to the surface and on the chain length and bulk of the molecule.

b. Mobility—the ability to reach the freshly exposed surface areas quickly.

c. "Contaminating" power—this determines the degree of protection afforded the freshly exposed areas when they have been reached. This involves the strength of attachment of the lubricant molecule to the surface, the closeness of packing, and the area effectively "contaminated" by each molecule.

6. A "perfect" lubricant would keep opposing rounded eminences separate even during plastic deformation and would prevent the formation of any bond whatever between freshly exposed surface areas resulting from the breaking of asperities. It would not reduce the coefficient of friction to zero, but to a value determined chiefly by the expenditure of energy in plastic deformation of

(*Continued on page* 238)



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SHELL INDUSTRIAL LUBRICANTS

CURRENT LITERATURE

(*Continued from page* 223)

manufacture an intermediate chemical used in making finished detergents.

Chemistry & Industry, No. 28, July 10, 1948

THE THEORY AND PRACTICE OF METAL DEGREASING IN AQUEOUS MEDIA
Liddiard, P. D.—pp. 435-437

The past has seen a battle between aqueous cleaning methods on the one hand and solvent degreasing on the other. Lists of claims have been made out for the effectiveness of one process to the detriment of the other. Some of the manufacturers of solution degreasing mixtures began to realize that trichlorethylene degreasing was an accepted part of many engineering processes and suggested that solution degreasing might be complementary to it. This was found to be particularly true in those processes employing a subsequent aqueous process such as electroplating, phosphate treatment, and even simple acid etching. Greater speed in cleaning is being obtained nowadays by the use of pressure spraying methods. The cleaning of aluminum and its alloys still presents problems owing to the ready formation of aluminum oxide on the surface. The nature of the tarnishing of multiphase alloys when cleaned by these methods is largely unexplored. More is becoming known, however, of the mechanism of corrosion and this work can be expected to be extended with more success to degreasing of metals in aqueous solutions.

Diesel Power & Diesel Transportation, Vol. XXVI, No. 7, July, 1948

PRACTICAL ENGINE ROOM TESTS OF LUBRICATING OIL CONTAMINANTS
Gerin, F. L.—pp. 60-62, 64

The author describes the significance and simplicity of the important lubricating oil tests which can be performed with the aid of newly developed equipment. It is pointed out that continuity of testing is important for practical oil evaluation and that notice of a variation in the rates of oil contamination is a sensitive means of determining incipient troubles.

NEW GEAR LUBRICANT
Anon.—p. 82

The Socony-Vacuum Oil Co. has announced a new line of gear lubricants which are claimed to be equally suitable for the lubrication of all automotive rear axles and manually-shifted transmissions and overdrives. Designated as Mobilube GX-80, 90 and 140, the new gear-lubricant line is of the multi-purpose type and is available in three grades identical in composition and performance properties and differing only in body or viscosity characteristics.

LUBRICATOR VALVE
Anon.—p. 83

A new lubricator valve that delivers a positive metered amount of oil or grease to each bearing in lubricating systems has just been announced by Titeflex, Inc. Known as the Grannan Lubricator, it dispenses all lubricants from light oil to heavy greases through the same valve without alteration.

Fuel Abstracts, Vol. III, No. 5, May, 1948

GROWTH OF LIQUEFIED PETROLEUM GAS INDUSTRY. 2931
White, H. D.—p. 37
(Pap. to Nat. Warm Air Heat and Air Condit. Ass. Conv., 5 Dec., 1947) (Amer. Artisan, Vol. CXVI, No. 12, Dec., 1947, pp. 109-111, 164-168)

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TARS, PITCHES, AND WAXES AND THEIR DANGERS. 2953
Bouyeure, P.—p. 42
(Chim. et Industr., 1948, Vol. LIX, pp. 87-89

OXIDATION OF MINERAL OILS. 2982
Stager, H.—pp. 48-50
(Schweiz. Arch. Ang. Wiss. Tech., 1947, Vol. XIII, pp. 257-268, 289-299, 344-356, 376-379)

DIESEL FUELS. 2983
Anon.—p. 50
(Pwr. Generation, Jan., 1948, Vol. LII, No. 1, p. 76-78)

TREATMENT OF MINERAL ENGINE LUBRICATING OILS FOR LUBRICATION. 2992
Kuipers, Y. A.—p. 52
(Schip en Werf, 9 Jan., 1948, Vol. XV, p. 10) (Dutch)

The paper deals with only pure mineral oils which do not contain additives. The Author discusses the requirements of the engine operator from the oil supplier and simple lubricating-oil test methods which can be used aboard ship.

GREASE LUBRICATION — SWELLING OF SOAPS IN NON-AQUEOUS LIQUIDS. 2993
Mardles, E. W. J. and Clarke, E. B.—p. 52
(Trans. Faraday Soc., 1946, Vol. XLII B. pp. 295-302)

POLYMERISATION TO LUBRICATING OILS OF N-HEPTENE-1 AND N-PENTADECENE-1. 3038
Dazeley, G. H. and Hall, C. C.—p. 63
(J. Soc. Chem. Industr., Jan., 1948, Vol. LXVII, pp. 22-23)

(*Continued on page* 239)

(*Continued from page* 235)

opposing eminences after the elastic limit had been exceeded and by the amount of interlocking and rupture of small asperities.

7. Ways in which friction is produced under boundary lubricated conditions are listed in decreasing order of importance.

a. Inelastic deformation of rounded eminences on the surfaces.

b. Seizure between areas freshly exposed during severe deformation of rounded eminences.

c. Actual sliding between surface layers of lubricant separating opposing rounded eminences. It seems likely that the local pressure will often become so high as to cause a great increase in the viscosity of the few layers of lubricant molecules held between the approaching surfaces by adhesive and cohesive forces. The contribution of this to the total friction may well be important, though by no means as great as that of causes (a) and (b) above.

d. Trapping of lubricant in localized pockets. Contacts between the rubbing surfaces occur over areas separated from each other by distances large compared with their extent. Some localized pockets will be formed, trapping the lubricant under hydrodynamic conditions. Presumably the pressure will be sufficiently high to increase greatly the viscosity of the lubricant. Even so the coefficient of friction is very small, and the probable number of trapping regions is small, so that their contribution to the total friction will be even less than that of cause (c) above.

It is somewhat unfortunate that Mr. Bikerman's Table II, in which he gives his interpretation of the "coefficient of sliding," should appear at the end of his paper, since in his earlier discussion of "friction" he is apparently talking about phenomena which are much more limited than are those customarily associated with this term. It seems to the writer to be much preferable to use the term friction to describe the resistance to sliding which occurs when one body slides over another, and to define, if one wishes to, subclasses of friction whenever a certain specific behavior appears to predominate. On this view a phenomenon of scratching or plowing is merely a subclass of the general class of frictional phenomena. In any case, it is clearly desirable to define one's terminology as clearly as possible if one is to avoid the very difficulty which Mr. Bikerman emphasizes in his introduction.

It seems to the writer that Mr. Bikerman's discussion of the mechanical theory of friction suffers from the apparently implicit assumption that the hills and valleys of the surface are bounded by arbitrarily rigid material. It is well known that this is not so, and that the plastic and elastic deformation of the surface irregularities play an important part in the observed frictional work. The discussion of the effects based on Stefan's equation seems highly idealized, inasmuch as the individual hills and valleys are connected by relatively rigid solid material so that the chance for a given hill to sink into a given valley is lessened more by the fact that this hill is part of a large piece of solid material than by the viscosity of the lubricant which may be present.

The writer would like to call attention to the existence of an improved method of determining the nature of polished and flat surfaces which has been developed by S. Tolansky, Proc. Roy. Soc. Lond. *A, 186,* 261 (1946; *191,* 182 (1947).

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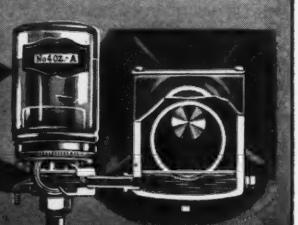

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NEWS OF INDUSTRY

(*Continued from page* 234)

NEW ADDITIVES BOOKLET

"Chemical Additives for Petroleum Lubricants" is the title of a new twenty-page educational booklet prepared by the American Cyanamid Company. It explains in non-technical language what additives are, why they are needed, when and where they are used, and how they improve lubricating oils. Numerous simple illustrations serve to assist the reader in understanding these complex subjects.

The booklet covers all of the commonly used types of lubricating oil additives, and its novel approach to the additive subject should make it of equal interest to manufacturers, marketers and users of additive-type lubricating oils. Copies may be obtained free of charge from American Cyanamid Company, 30 Rockefeller Plaza, New York 20, New York.

SOLUBLE OIL MIXER

A new soluble oil mixer for use in machine shops, industrial plants or wherever soluble oils are required as a lubricant and coolant in machining operations, has been announced by the Alemite division of Stewart-Warner Corporation.

This mixer performs three operations simultaneously. It proportions water and soluble oil, mixes them into a uniform emulsion, and transfers the soluble oil from the original drum into another container ready to pour into the machine sump or circulating system. The mixing unit is inserted in the bunghole of a drum of soluble oil, connected by a hose to a water outlet, and adjusted. Water pressure (average 24-30 pounds per square inch) is the only power required.

The compact unit weighs five and a half pounds. It eliminates need for hoists and racks for emptying drums, reduces spillage, and protects the oil from contamination, according to Alemite engineers.

The soluble oil mixer (Model 6780) is supplied with a two-inch pipe-thread sliding bung adapter for various heights of drums. It has a three-eighths inch female pipe-thread union inlet for water hose and a one-half inch male pipe-thread connection for outlet hose. Height is forty and three-eighths inches.

CURRENT LITERATURE

(*Continued from page* 237)

ETHYLENE-LUBRICATING OIL PROCESS. 3041
Zorn, H. and Ammoniakwerke, M.—p. 64
(Bd. of Tr., German Div., Tech. Information and Documents Unit, F.D. 5536/1947)

SCIENTIFIC PRINCIPLES OF LUBRICANT SYNTHESES. 3042
Zorn, H. and Ammoniakwerke, M.—p. 64
(Bd. of Tr., German Div., Tech. Information and Documents Unit, F.D. 5538/1947)

COMPARATIVE GAS CONVERSION OF SYNTHESIS GAS AND WATER GAS ON COBALT AND IRON CATALYSTS. 3043
Bahr—p. 64
(U. S. Dept. of Commerce, Off. Tech. Serv., PB L70, 159), Feb., 1940

MEDIUM PRESSURE SYNTHESIS OF PARAFFINS. 3044
Bahr—p. 64
(U. S. Dept. of Commerce, Off. Tech. Serv., PB L70, 159), Sept., 1939

PRODUCTION OF OILS FROM PRIMARY PRODUCTS OF GASOLINE PRESSURE-SYNTHESIS. 3045
Clar, D. R.—p. 64
(U. S. Dept. of Commerce, Off. Tech. Serv., PB L70, 185), Oct., 1940

MIDDLE PRESSURE SYNTHESIS WITH IRON CATALYSTS. 3046
Fischer, F.—p. 64
(U. S. Bur. Mines, Off. Synthetic Liquid Fuels, Louisiana, Mo., Transl. 1-423, 1 Dec., 1947, 8pp)

PARAFFIN SYNTHESIS ON IRON CATALYST. 3052
Ruhrchemie, A. G.—p. 66
(U. S. Dept. Commerce, Off. Tech. Serv., PB L70, 159), Sept., 1941

PARAFFIN SYNTHESIS WITH IRON CATALYST. 3053
Ruhrchemie, A. G.—p. 66
(U. S. Dept. Commerce, Off. Tech. Serv., PB L70, 159), Mar., 1941

PARAFFIN SYNTHESIS WITH AN IRON CATALYST. 3054
Ruhrchemie, A. G.—p. 66
(U. S. Dept. Commerce, Off. Tech. Serv., PB L70, 159), July, 1943

Industrial & Engineering Chemistry, Vol. XL, No. 7, July, 1948

SELECTIVE EXTRACTION OF VEGETABLE OILS WITH FURFURAL
Kenyon, R. L., Gloyer, S. W., and Georgian, C. C.—pp. 1162-1170.

The authors describe the selective extraction of vegetable oils with furfural by the Pittsburgh Plate Glass Company for the separation of vegetable oils of high and low iodine value. Fifty-two references are given.

PROPELLER INFLUENCE IN HIGH SPEED STIRRING
Morton, A. A., and Redman, L. M.—pp. 1190-1193

The present paper describes a test specifically related to the propeller action in high speed stirring and shows that increased effectiveness is attained by: (a) a high speed of rotation; (b) a large diameter propeller; (c) an appropriate blade angle that may preferably be 45°; and (d) a downward bend of the lower edge of the propeller blade. A discussion of a few special effects of stirring in chemical reactions is included.

Industry & Power, Vol. LV, No. 1, July, 1948

PREDICT ADEQUATE LUBRICANTS DURING NEXT FEW YEARS
Anon.—p. 106, 108

A. J. McIntosh, economist of the Socony-Vacuum Oil Company, Inc., New York, speaking in Tulsa, Oklahoma at a meeting of the lubricating section of the American Petroleum Institute, predicted that plenty of lubricants during the next four years will be available for American industries. He divided lubricants into two general classifications, automotive and industrial, and predicted that peak consumption within the United States in both classifications will be reached this year. The increasing and decreasing consumption of lubricants was discussed from the economic point of view.

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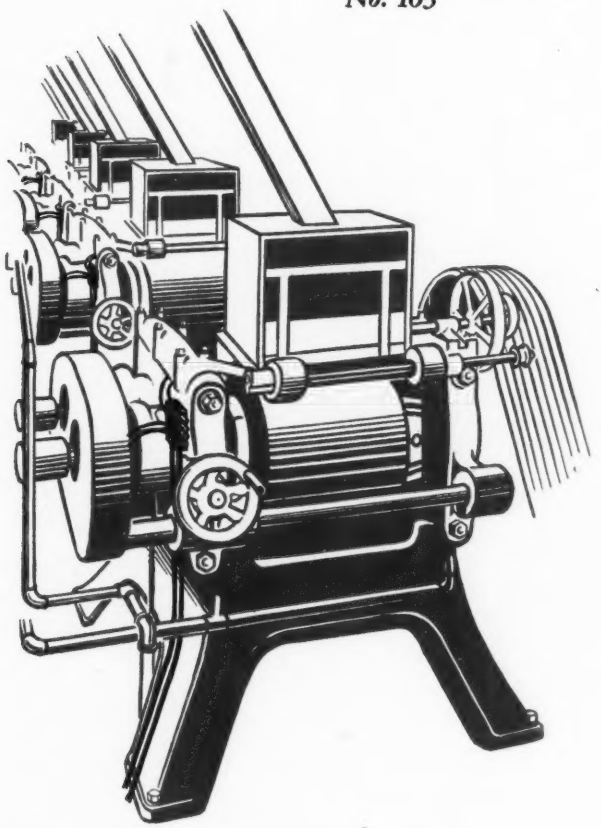

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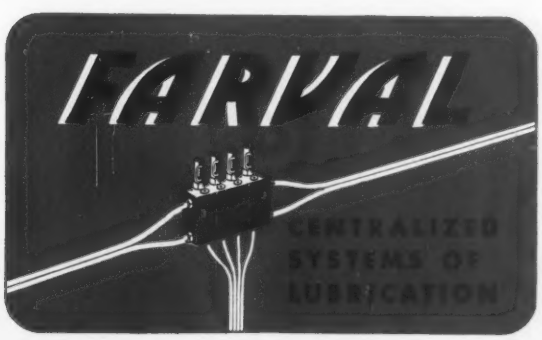

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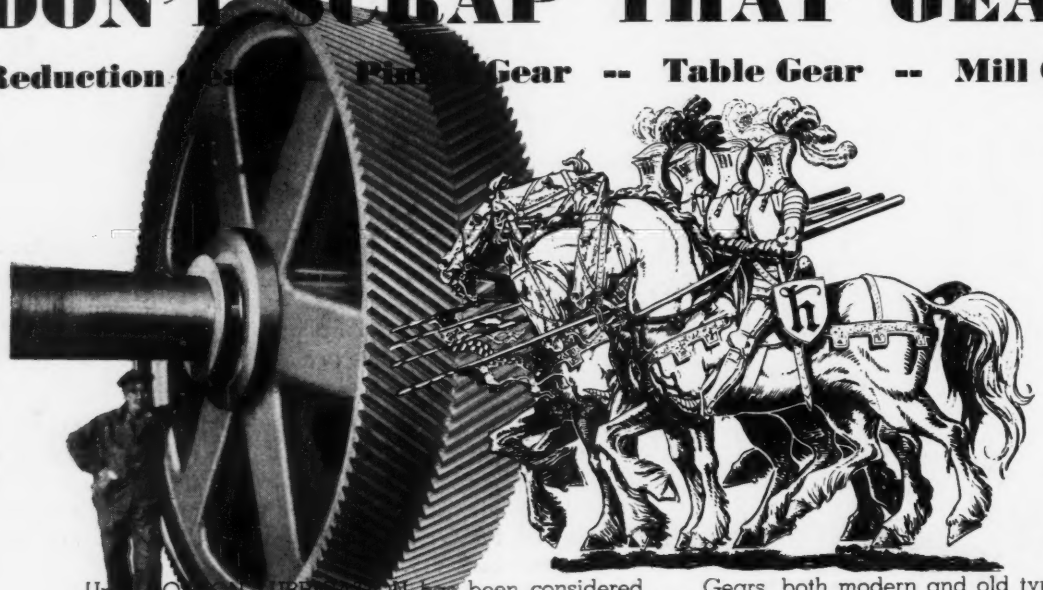

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